CONSERVATION ASSESSMENT OF ELEVEN SENSITIVE MOONWORTS

(*Ophioglossaceae; Botrychium* Subgenus *Botrychium*)

on the

IDAHO PANHANDLE NATIONAL FORESTS

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January 27, 2005

EXECUTIVE SUMMARY

This report summarizes current knowledge on the distribution, ecology, and conservation status of 11 species of moonworts (*Botrychium* spp.) on the Idaho Panhandle National Forests (IPNF). It is based on information gathered in the field by IPNF botanists, Idaho Conservation Data Center (ICDC) botanists, literature research, and related studies in other states.

The ICDC database, maintained by Idaho Department of Fish and Game (IDFG), was queried for known occurrences of the following 11 sensitive *Botrychium* species on the Idaho Panhandle National Forests: *Botrychium ascendens* (upswept moonwort), *B. crenulatum* (dainty moonwort), *B. lanceolatum* (triangle moonwort), *B. lineare* (slender moonwort), *B. 'michiganense'* (Michigan moonwort), *B. minganense* (Mingan moonwort), *B. montanum* (western goblin), *B. paradoxum* (paradox moonwort), *B. pedunculosum* (stalked moonwort), *B. pinnatum* (northwestern moonwort), and *B. simplex* (least moonwort).

There were 183 records in the database for Idaho from the ICDC, four site occurrences on file with United States Forest Service (USFS), and one occurrence of '*B. michiganense*' was not recorded in the ICDC database because it is not currently a formally recognized nomenclature (refer to Appendix E for Element Occurrence (EO) data table and Appendix F for EO data maps). Of the 183 total sites, 143 are located on the IPNF and include the following:

- five *B. ascendens* (four within the IPNF),
- three *B. crenulatum* (two within the IPNF),
- 58 *B. lanceolatum* (53 within the IPNF - five sites are represented with more than one point on the EO map),
- one *B. lineare* within the IPNF,
- one *B. 'michiganense'* within the IPNF,
- 60 *B. minganense* (43 within the IPNF - 10 sites are represented with more than one point on the map and one site is not found in the ICDC database, but is on file with the USFS),
- 17 of *B. montanum* (14 within the IPNF and four sites are represented with more than one point on the map),
- one *B. paradoxum* within the IPNF,
- four *B. pedunculosum* (three within the IPNF and one (EO #3) is actually the *B. 'michiganense'* EO, but was originally turned in as *B. pedunculosum*),
- 20 *B. pinnatum* (17 within the IPNF and 1 site represented with more than one point on the EO map), and
- 14 *B. simplex* [seven within the IPNF – two sites are incorrectly shown outside the IPNF boundary in the ICDC mapping database (EO #5 and #15)]

IPNF botanists and other knowledgeable local individuals were interviewed to obtain leads on other possible moonwort sightings that were not entered in the database. The herbarium at the IPNF main office in Coeur d'Alene was searched for collections of moonworts on the IPNF.

The population size of *Botrychium* species varies on the IPNF. The largest populations are of *B. lanceolatum* and *B. minganense*. The second largest populations are of *B. montanum, B. pinnatum,* and *B. simplex*. The third largest populations are of *B. ascendens, B. pedunculosum*, and *B. crenulatum*. Extremely rare species with only one occurrence documented included *B. lineare*, *B. paradoxum*, and *B. 'michiganense'*. *Botrychium 'michiganense'* is not a formally accepted species in Idaho and has been placed in a review category by the ICDC

until it is officially published in a peer review journal and the nomenclature is accepted by a panel of experts (Swartz 2004 pers. comm.).

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1. DESCRIPTION OF THE SUBGENUS *BOTRYCHIUM*

Sections 1.1, 1.2, and 1.3 provide background information on taxonomy, life history, and mycorrhizal associations that is common to all moonworts. Because many of the moonworts discussed in this report are found in similar habitats on the Idaho Panhandle National Forests, present or potential threats and management activities, past and current conservation activities, research and monitoring activities, and survey suggestions (Sections 1.5, 1.6, and 1.7) that are common to all 11 moonworts are also outlined under this heading. These sections are followed by information particular to each individual moonwort species on the Idaho Panhandle National Forests.

1.1 Nomenclature and Taxonomy

Moonworts are primitive ferns belonging to the subgenus *Botrychium* of the genus *Botrychium* in the *Ophioglossaceae* family (Gifford and Foster 1989). The genus *Botrychium* includes the grapeferns (subgenus *Sceptridium*), rattlesnake fern, (subgenus *Osmundopteris*), and moonworts (subgenus *Botrychium*).

Subgenus *Botrychium*, the moonworts, are diverse species of rare, localized, and very small perennial plants that are difficult to find and positively identify. There are currently 34 species of *Botrychium* described (USDA, NRCS 2004), but this number is constantly changing as new species are discovered. Because the taxonomy of moonworts is based on subtle distinctions in morphology, disagreements and controversy on plant identification and species validity are common. Identification of moonworts is often complicated because the species have characteristics that may not be apparent in small plants, a high degree of morphological variability, and because several species may grow together at the same site.

The subgenus *Botrychium* has undergone extensive revision since the writing of Cronquist (1969), Hitchcock and Cronquist (1973) and Wagner and Wagner (1994), including the addition of recently described species and the elevations of some previously recognized varieties or subspecies to full species status.

This report describes the following 11 moonwort species documented or suspected to occur on the Idaho Panhandle National Forests:

- *B. ascendens* (upswept moonwort)
- *B. crenulatum* (dainty moonwort)
- *B. lanceolatum* (triangle moonwort)
- *B. lineare* (slender moonwort)
- *B. 'michiganense'* (Michigan moonwort)
- *B. minganense* (Mingan moonwort)
- *B. montanum* (western goblin)
- *B. paradoxum* (paradox moonwort)
- *B. pedunculosum* (stalked moonwort)
- *B. pinnatum* (northwestern moonwort)
- *B. simplex* (least moonwort)

1.2 Life History

Moonworts are primitive ferns producing one aboveground leaf (frond) divided into two parts, the trophophore and the sporophore, which share a common stalk. The trophophore is usually sterile and consists of leaf segments that are typically linear and divided or forked at the ends (USFWS 2000). The sporophore is usually fertile and consists of grape-like sporangia containing spores. The spores germinate and develop into tiny

underground gametophytes, which are rarely seen and are difficult to study. Mature moonwort sporophytes generally produce a single fertile frond per growing season, but prolonged dormancy has been documented for several species (Johnson-Groh and Farrar 1993, Lesica and Ahlenslager 1996). Both generations of the ferns are associated with mycorrhizal fungi (discussed in Section 1.3).

As mentioned earlier, survey and field determination of moonworts are complicated by their species biology. They are small and difficult to find, they often occur in "genus communities" (Wagner and Wagner, 1983), they cannot be identified with certainty in their immature stages, and fronds may emerge from the ground over a three-month span during favorable growing seasons, or not appear at all during unfavorable seasons.

Available information indicates that members of subgenus *Botrychium* (moonworts) are generally short-lived perennials while subgenus *Sceptridium* (grapeferns) are more long-lived (Montgomery, 1990, Muller 1993, Kelly 1994, Lesica and Ahlenslager, 1996). Estimated lifespans for various grapeferns were 43.2 years (Montgomery, 1990) and 11.2 years (Kelly, 1994), while moonwort lifespans were 1.3 years (Muller, 1993) and three years or less (Lesica and Ahlenslager, 1996). However, *Botrychium multifidum* has been documented to live more than 100 years (Stevenson 1975).

Numerous hybrids between different species of moonworts have been found (Wagner et. al. 1985, Wagner 1991, Wagner 1993). Wagner and Wagner (1988) described a hybrid between *B. lanceolatum var. angustisegmentum* and *B. matricariifolium* from Michigan that possessed abortive spores and were intermediate in characteristics between the presumed parents (Wagner, 1993). Chromosome number has been useful in recognizing the distinctness of a new species. Some species may have arisen through allopolyploids of interspecific hybrids (Wagner 1993). Farrar and Wendel (1996) found that hybrid *B. lanceolatum* var. *angustisegmentum* is considered one putative parent for several species in the *B. matricariifolium* complex. They also found that the *B. lanceolatum* var. *angustisegmentum* of eastern North America was genetically distinct from the western variety *B. lanceolatum* var. *lanceolatum*. Similarly, a tetraploid hybrid of *B. lineare* and *B. campestre* has been documented from the Sawtooth Mountains in southern Idaho (Farrar, 2004, pers. comm.).

The moonwort sporophyte begins its life after fertilization of an egg by a sperm of the gametophyte. Spores are small and lightweight enough to be carried by air currents, which explains the broad and often disjunct distributional patterns that are often exhibited by ferns, including moonworts (Barrington, 1993, Peck et al., 1990). Dispersal of moonwort spores by droppings of small mammals has also been suggested (Zika, 1992). This method of dispersal may help explain the tendency of moonworts to grow in patches and may be especially important for dispersal in forest environments with little wind. It has been documented that spores on herbarium sheets germinated after over 50 years, demonstrating potential for a soil spore bank (Dyer and Lindsay, 1992).

In nature, *Botrychium* spores germinate underground, and development of the haploid, nonphotosynthetic gametophyte is dependent on early infection by an endophytic fungus (Bower 1926, Gifford and Foster 1989). Spore germination requires variable periods of darkness depending on the species (Whittier 1981). After the spores are released, they infiltrate into the soil and may germinate. Infiltration and subsequent germination may take up to five years, although some may germinate immediately (Casson et al., 1998). Spore germination requires darkness, (Whittier, 1972, Whittier, 1973), a requirement that is not surprising in view of the subterranean habitat of the gametophyte and the need for the resultant gametophyte to be infected by an endophytic fungus in an obligate association (Whittier, 1973). Gametophytes of *Botrychium* species can be

grown in sterile culture without a fungal symbiont if a suitable source of soluble sugars is supplied (Whittier, 1984).

Botrychium gametophytes are bisexual with the antheridia positioned above the archegonia (Bower 1926, Campbell 1922, Gifford and Foster, 1989), facilitating self-fertilization, an advantage for colonizing following long distance spore dispersal (Peck et al., 1990). The spores have been measured to disperse by wind about one meter (Hoefferle 1999), but may potentially travel much less, perhaps only a few centimeters (Casson et al., 1998). Peck et al. (1990) found that *B. virginianum* spores landed within three meters of the source if the plant was above the herbaceous layer, but much less when the sporophore was within the herbaceous layer. Most fertilizations are likely due to inbreeding, since the antheridia and archegonia are nearby and enzyme electrophoresis indicates a lack of genetic variability (McCauley et al. 1985, Soltis and Soltis 1986, Farrar and Wendel 1996 and Farrar, 1998). However, there is no reason that cross-fertilization should not occur (Wagner et al., 1985), especially in consideration of the existence of interspecific hybrids (Wagner et al. 1985).

Farrar and Johnson-Groh (1990) have documented underground gemmae (bud-like structures) in a few species of moonwort. They speculated that asexual reproduction may have evolved as an adaptation to the dry habitats that some moonwort species are found in. Self-fertilization may be the norm due to limited range of the flagellated sperm in the soil (Barrington 1993) and high levels of inbreeding have been demonstrated for some *Botrychium* species based on electrophoretic evidence (Soltis and Soltis 1986). However, the occurrence of interspecific hybrids that exhibit hybrid vigor may be evidence of intergametophytic crossing (Ahlenslager and Lesica, 1995).

Campbell (1922) reported that in *Botrychium simplex* several archegonia of a gametophyte may be fertilized at about the same time, but only one embryo was found to develop. Gametophytes with two embryos were reported for *B. lunaria*. The gametophyte, with its fungal associate, is thought to nourish the young embryonic sporophyte (Camacho 1996). Some moonwort species are distinguished by having the gametophyte remaining attached to the mature sporophyte (Wagner and Wagner, 1981). The longevity of gametophytes and their fate following maturation of an associated sporophyte has not been reported.

Early morphological studies (Campbell, 1922) described a diversity of patterns of embryo development among moonworts. For example, *Botrychium* simplex has a relatively large cotyledon and rapid development, perhaps capable of maturing a small aboveground fertile frond in its first year; while *B. lunaria* has a relatively small cotyledon, and may take as much as seven years to produce an emergent frond.

Gametophytes and young sporophytes may exist underground for many years before an aboveground plant develops (Campbell 1911, Muller 1993). Mortality may be high during this period (Peck et al., 1990). The gametophyte produces male and female gametangia; fertilization of eggs occurs via free-swimming sperm under wet conditions (Lesica and Ahlenslager, 1996). Sporophytes develop on the gametophyte, forming roots and a single leaf each season from a short rhizome (Foster and Gifford 1974). Root development occurs before any leaf development (Casson et al. 1998), and the roots must be colonized by mycorrhizal fungi for a nutrient source (Farrar and Johnson Groh 1990, Wagner 1998, Johnson-Groh, 1998). The fungus involved is believed to be a vesicular arbuscular mycorrhizae (Berch and Kendrick, 1982), which penetrates inside the plant cells of both the roots and the gametophytes in the case of *Botrychium* spp. The fungus may be transferring carbohydrates from other photosynthesizing plants in the vicinity, probably species of herbaceous flowering plants (Farrar 1998). *Botrychium* may depend little on photosynthesis because the mycorrhizae alone may supply a significant amount of the plant's nutrients and energy (Johnson-Groh 1999, Casson et al., 2000).

1.3 Mycorrhizal Relationships

All *Botrychium* species are believed to be obligately dependent on mycorrhizal relationships in both the gametophyte (Bower 1926, Campbell 1922, Gifford and Foster 1989, Scagel et al. 1996, Schmid and Oberwinkler 1994) and sporophyte generations (Bower 1926, Gifford and Foster 1989, Wagner and Wagner 1981). The gametophyte is subterranean and achlorophyllous, depending on an endophytic fungus for carbohydrate nutrition, while the roots of the sporophyte lack root hairs and probably depend on the fungal symbiont for absorption of water and minerals (Gifford and Foster 1989). *Botrychium* gametophytes were considered saprophytic (Bower 1926), but are now thought to obtain carbohydrates fixed by neighboring plants and transported by shared mycorrhizal fungi (Camacho 1996); they are thus better classified as myco-heterotrophic (Leake 1994).

The gametophytes cannot utilize complex carbohydrates (starch, cellulose etc.) but can be grown in sterile culture without a fungus if they are supplied with a source of soluble sugars (Whittier 1984). In nature, a fungal associate is present within the plant at the earliest stages of development of the gametophyte and sporophyte (Bower 1926). In the gametophyte, fungal infection is confined to the interior of the prothallus; areas of apical growth and the sexual organs are left uninfected (Bower 1926, Campbell 1922). There are no reports of successful completion of the lifecycle by *Botrychium* species without fungal infection; however, the degree of infection may vary between species and age of plants (Bower 1926, Campbell 1922).

The mycotrophic condition is important to the ecology of *Botrychium* species in several ways. Nutrition supplied through a fungal symbiont may allow the ferns to withstand repeated herbivory, prolonged dormancy, or growth in dense shade (Kelly 1994, Montgomery 1990). The fungal/fern relationship has implications for the occurrence of genus communities, the distribution of the species across the landscape, and associations with particular vascular plants. Mycorrhizal links may explain the often-observed close associations between certain moonworts and strawberries (*Fragaria* spp.) (Zika 1992, 1994) and between grapeferns (*Botrychium* subgenus *Sceptridium*) and Rosaceous fruit trees (Lellinger 1985). Due to the occurrence of heterotrophic life-stages, moonworts share many of the morphological and habitat characteristics of myco-heterotrophic plants such as orchids (Leake 1994) and in many respects behave much like mushrooms (Zika 1994).

Arbuscular (also referred to in the literature as vesicular-arbuscular) mycorrhizae are the known fungal symbionts with *Botrychium* species (Berch and Kendrick 1982, Schmid and Oberwinkler 1994). Little is known about the specific nature of mycorrhizal interactions in *Botrychium* species. Johnson-Groh (1999) found that water relations were extremely important for mycorrhizae and *Botrychium*. Farrar (1998) notes that mycorrhizal fungi are low in species diversity, ubiquitous in disturbed and undisturbed sites, and generalists in whom they infect (Smith and Read 1997). Recent studies have measured surprisingly high species diversity of arbuscular mycorrhizal (AM) fungi in a single hectare (Bever et al. 2001). A single plant root has been observed to host up to 49 species of AM fungi simultaneously (Vandenkoornhuyse et al. 2002). These observations, coupled with the ubiquity and low host specificity of AM fungi, suggest that mycorrhizae may not be a limiting factor in the distribution of *Botrychium* species.

1.4 Population Biology and Viability for all Botrychium Species

Population studies on certain species of moonworts have shown that there is considerable annual variation in the number of aboveground plants at a given site (Johnson-Groh 1999). Populations fluctuated independently among plots at any given site, some populations may be increasing while others are decreasing (Johnson-Groh 1999). These variations reflect microsite differences such as soil moisture, herbivory, or mycorrhizae, although populations of moonworts are known to fluctuate wildly without any apparent cause (Johnson-Groh 1999). Individual plants may not emerge every year (Muller 1993, Johnson-Groh 1998). *Botrychium* probably appear or

disappear in accordance with mycorrhizal health (Johnson-Groh 1998) due to their obligate relationship with the fungi. Johnson-Groh (1999) concluded that mycorrhizae are the most limiting factor for *Botrychium* establishment, distribution and abundance. Environmental factors that may affect mycorrhizae, like reduction in water availability, are then also likely to have significant impacts on moonworts, whereas the repeated removal of leaf tissue may have little effect (Johnson-Groh 1999). Wagner and Wagner (1993) also concluded that taking many samples would have little effect on the population as long as the underground shoots and roots are left intact. Standard assumptions about the population biology of other more 'typical' plants may be irrelevant to *Botrychium* because of this obligate relationship (Johnson-Groh 1999).

Since there is considerable variation in the numbers of aboveground sporophytes, a measurement of only sporophytes does not completely indicate population numbers. Johnson-Groh (1998) developed a method to extract *Botrychium* gametophytes and belowground sporophytes from soil samples. Up to 7,000 gametophytes and 250 non-emergent sporophytes per square meter of soil have been recovered (Johnson-Groh 1998). In another report Johnson-Groh et al. (2000) found gametophyte populations ranging from up to 2,000 gametophytes per square meter for some moonwort species; other moonwort species had a much lower density. Bierhorst (1958) reported finding 20 to 50 gametophytes of *B. dissectum* beneath each square foot surface with a predominance of younger gametophytes versus older ones with attached sporophytes. These findings suggest that a single emergent sporophyte may indicate a self-sustaining population at that site (Casson et al. 1998).

A spore-bank that consists of all ungerminated spores, including unopened sporangia, is present within the litter, duff, and soil (Casson et al. 1998) of most *Botrychium* sites. The spores persist in the soil for several years and, along with underground gametophytes and developing sporophytes, form a highly buffered moonwort population that can rebound from unfavorable years (Johnson-Groh 1998, 1999). However, events that destroy the sporophytes, like an herbicide application, may have effects several years later (Johnson-Groh 1999). These underground stages have been compared to seed-banks in angiosperms and likely play an important role in population dynamics (Kalisz and McPeek 1992). A population model for *Botrychium mormo* has been developed by a working group within the Population and Habitat Viability Assessment Effort (Berlin et al. 1998 and Johnson-Groh et al. 1998). This model uses a variety of input variables such as number of spores in the soil, number of soil gametophytes, frequency of catastrophes, etc. They concluded that populations subjected to increased levels of annual environmental variation are at greater risk of population decline and extinction, although a single catastrophic year has relatively little effect on simulated populations. The population is likely more stable than would be predicted from monitoring only aboveground plants due to the large proportion of the population in underground stages.

1.5 Current or Potential Threats to Habitat and Management Activities

The National Forest land within the Idaho Panhandle National Forests is divided into 19 Management Areas (MAs), each with different goals, resource potential and limitations. The 11 *Botrychium* species documented in this report are located on 10 different MAs within the Idaho Panhandle National Forests. A majority of the EO's on the Idaho Panhandle National Forests are located in MAs that are allocated for timber production. These MAs include the following: MA1 (Timber), MA 2 (Timber Grizzly Bear Habitat), MA 3 (Timber Grizzly Bear Big Game Winter Range), MA 4 (Timber Big Game Winter Range), MA 6 (Timber Big Game Summer Range), and MA 7 (Timber Caribou). The MAs that are not allocated for timber production include: MA 9 (Minimum Management Areas), MA 13 (Special Areas), MA 14 (Research Natural Areas), and MA 19 (Semi-Primitive Recreation With Roads). While no scheduled timber harvesting occurs on lands within these MAs, other activities such as grazing, mining, road maintenance, trail maintenance, and prescribed fires may occur (USDA 1987).

The following USFS forest management activities may occur in the above listed MAs and may potentially threaten *Botrychium* species on the Idaho Panhandle National Forests:

- **Timber harvest** involves a "felling" phase, "yarding" phase, and fuels reduction phase. "Felling" can be accomplished by hand sawing or mechanized felling and "yarding" the trees to a landing after the trees are "felled" can be accomplished by ground-based skidding, cable yarding, and helicopter yarding. Fuels reduction following harvest involves piling and burning scattered woody debris and/or "broadcast burning of unpiled debris.
- **Fuels reduction** for ecosystem restoration and habitat enhancement may involve ecosystem burning to enhance forest structure, develop desired species composition, and regulate down woody fuels/ wildfire risk or wildlife burns to enhance forage production and habitat for wildlife.
- **Aquatic restoration activities** may include woody debris placement in streams, streambank stabilization, and stream channel reconstruction.
- **Noxious weed treatment** may include herbicide spraying, mechanical mowing or excavation, hand pulling, and biological control.
- **Trail maintenance** activities occur within existing trail corridors and involve minimal soil disturbance or excavation. Generally, the work involves the removal of logs, brush and debris within specified clearing limits using common hand and power tools. Water bars, drainage dips, and other trail structures may be cleaned and/or repaired if not functioning as intended.
- **Trail construction** generally consists of a ground disturbing activity that typically involves clearing, grubbing, drainage work, and sometimes rock removal. Construction is done through mechanical or hand means. Depending upon what user class (hiker, horseback, ATV) the trail is constructed for, trail treads range from 24 to 84 inches wide and trail clearance from six to eight feet wide.
- **Trail reconstruction activities** are limited to non-routine major repairs or realignments to existing trail surfaces and replacement or construction of trail structures within the existing trail corridor areas. Trail reconstruction activities do not involve new soil disturbances outside of the existing trail corridor area, but often result in a greater degree of soil disturbance than routine trail maintenance activities.
- **Trail relocation activities** often involve identification of alternative trail routes, trail obliteration, new soil disturbances, and excavation to construct new trails surfaces.
- **Maintenance of signs, cattle guards and other structures (gates and barriers)** typically includes minor excavation to install posts, cleaning of cattle guards, cleaning and painting or replacement of sign placards, or cleaning and painting of metal parts on bridges, cattle guards, replacement of gate posts, cross bars and other structures. The primary purpose of these repairs is to maintain visibility requirements for signs and to repair damaged caused by collision, weather or aging processes.
- **Drainage maintenance and culvert cleaning** includes removal of fine and coarse materials and brush from catchbasins, inlets, outlets, outlet channels, leadoff ditches, trash racks, drop inlets, water bars, opentop culverts, and rolling dips. Commonly, repairs would utilize a variety of equipment ranging from simply cleaning culvert inlets with a shovel up to and including the use of backhoes, motor graders or front-end loaders to remove heavy accumulations of debris.
- **Culvert and bridge replacement** can include minor concrete work, e.g. installation of small headwalls. Riprap slope protection, prism reconstruction, retaining walls for slope stabilization, seeding and mulching will typically occur. Riprap placement for culvert inlet and outlet protection and bridge repairs will typically occur.

- **New road construction** generally consists of a ground disturbing activity that involves the removal of vegetation and the movement of soil through mechanized means. Road widths typically range from 12 to 18 feet on Forest Service lands within the Idaho Panhandle National Forests and may include additional disturbance from ditching and construction of turnouts.
- **Travelway maintenance** includes the removal of any vegetation or other material that is blocking the road and preventing access by seasonal traffic and/or use for any other reasons. All parts of down trees and other material are disposed by scattering outside of the clearing limits, piling off of the roadway, or used as a filter windrow at the toe of the fill. Disposal of cuttings is generally on site unless there is an inadequate disposal area or hauling of cuttings would facilitate other resource objectives such as visual quality, or reduction of fuels hazard.
- **Cutslope maintenance** is normally limited to brush removal to maintain sight distance for drivers, but cutslope failures (slumps, slides) result in excess material delivered to the ditch or travelway and may require extensive work to correct the immediate and underlying problem. These activities are more fully described below under the Ditch Maintenance section.
- **Roadside brushing** is performed on the unrestricted open road system (arterials and multipurpose collector roads) to assure safe viewing distance and maintain roadway drainage system. Brushing typically involves a combination of machine brushing and hand work. Hand work is most appropriate near streamcourses or areas where only limited amounts of vegetation needs removal. Brushing by hand allows the retention of as much surface stabilizing vegetation as possible. No more vegetation would be removed than necessary.
- **Ditch maintenance** is usually initiated to allow continued proper drainage of the road and efficient function of the ditch. Removal of undesirable materials is accomplished by hand or heavy equipment. Heavier maintenance includes ditch "pulling" and/or ditch "heeling", depending on the amount and size of the obstructing material. Ditch pulling involves the use of a bladed machine, such as a road grader, which cleans the ditch by running the blade along the bottom and sides of the ditch, thereby removing most or all of the excess embedded material. As much usable material pulled from the ditch as possible would be incorporated in to the road surface. Ditch heeling involves bladed machinery, such as a grader or backhoe, which is used to push excess material back up against the cutslope.
- **Clearance of slide material, slope failures, boulders and end-hauling.** When a cutslope failure has occurred within a Riparian Habitat Conservation Area (RHCA), resulting in excess material in the ditch or roadway, a temporary ditch may be constructed around the slide to channel the water to a more desirable location. A long-term solution generally involves removal of excess material and restoration of original ditch function, although removal of excess material carries with it the risk that the cutslope will be undercut and destabilized. Material not capable of being incorporated into the road surface will be removed to an appropriate disposal location.
- **Fillslope maintenance** includes problems such as surface erosion, slumps/cracks, lack of vegetation, and scour or erosion below culverts. These problems are generally corrected by improving drainage of the road surface (constructing more frequent cross drains and leadoff ditches) and armoring the scoured area below culverts. Heavier maintenance usually requires heavy equipment to bring in large amounts of fill and/or rock (rip rap) structure to rebuild or reinforce the fillslope. Brushing to improve sight distances can also occur.
- **Surface maintenance** can involve surface blading to keep the roadbed in a condition to allow traffic and provide drainage. Blading removes ruts, potholes, and washboarding, corrects improper templates, improves drainage, and temporarily corrects cracks and slumps. Blading maintains the crown or slope of the roadway and includes the shoulder, drainage dips, leadoff ditches, berms, and turnouts.

- **Rotomilling** is often done on roads that have limited material to correctly shape the road prism. The rotomill grinds up bedrock and boulders and produces a finer material that can be effectively bladed, shaped, and then compacted.
- **Dust abatement** is often done on roads that have high traffic volume. Dust control is applied to help maintain fines and road surfacing. It is also used for public health and safety needs on these heavily used roads.
- **Snow removal** occurs to insure safe and efficient transportation and to prevent unacceptable erosion damage to roads, streams, and adjacent lands. Removal includes the entire road width and turnouts. Snow slides, minor earth slides, fallen timber, and boulders that obstruct normal road surface width, including turnouts, are also removed. Culverts and ditches are cleared to assure that drainage will function effectively.
- **Recreation management** involves the use of motorized travel, foot travel, horse use; camping and use of dispersed recreation sites.
- **Grazing.** The specific effects of grazing on the species are unknown, although if grazing by livestock or wildlife species occurs prior to the maturation and release of spores, the capacity for sexual reproduction of affected plants may be compromised (USFWS 2000).
- **Special Forest Products collection** (personal use and commercial use) i.e., beargrass, floral greens, pinecones, seed, etc.
- **Mining.** Many mining activities on the Idaho Panhandle National Forests occur close to streams.
- **Silvicultural treatments** may include stand tending (precommercial thinning and release), reforestation, and site preparation (slashing, broadcast burning).

Some of these threats may have a direct effect on the aboveground sporophyte but may be less serious, since the belowground part of the life cycle is so important. Simple removal of leaf tissue may be inconsequential to the ability of moonworts to survive, although removing sporulating individuals may eventually have an effect (Johnson-Groh 1999). Wagner and Wagner (1993) also stated that as long as the underground shoots and roots are left intact, taking many samples has little effect on the population. However, Hoefferle (1999) found that if the aboveground plant was removed after spore release, the trophophore the following year was significantly smaller. It should be noted that this was a one-year study and weather conditions could have had an impact (Hoefferle, 1999). Longer studies have indicated that the removal of leaves had no effect on subsequent leaf size or vigor (Johnson-Groh and Farrar 1996).

Road maintenance activities that occur prior to spore maturation and dispersal could adversely affect the reproduction of *Botrychium* species. The effects of herbicide spraying on *Botrychium* are currently unknown. Future surveys on the Idaho Panhandle National Forests should provide more information on the status of roadside populations.

The relationship of habitat succession and fire suppression to the persistence of *Botrychium* is unclear. For example, in a biological assessment for sensitive plants in the Lostine River Canyon, a U.S. Forest Service botanist notes that "*Botrychium* species seem to be found in areas that receive natural disturbances, such as fire and landslides, but we are not yet able to predict what disturbance interval or successional stage best suits them'' (Hustafa 1999). Controlled (prescribed) fires or wildfires could also affect habitat for *Botrychium*, but the response of this species to fire is not currently known. In some cases, wildfires or controlled fires create high ground temperatures that may sterilize the soil and eliminate fungal species that are necessary for the survival of moonworts (Zika 1992). Research on the autecology of *Botrychium* on the Idaho Panhandle National Forests

is needed, particularly regarding its responses to forest management practices such as logging, road work, burning, grazing, disturbance, and succession. An assessment of population trends in known colonies in wild and human-influenced habitats may provide insight on types and periodicity of disturbance that creates and maintains suitable habitat for *Botrychium* species. This research will be important for identifying appropriate management practices.

Species of the subgenus *Botrychium* are not a source for human food, nor are they currently of commercial horticulture interest. Therefore, overutilization is not considered to be a threat to these species at the present time (USFWS, 2000). While disease is not currently known to be a threat to *Botrychium* species, populations may be affected by grazing by livestock or wildlife. The specific effects of grazing on the species are unknown, although if grazing by livestock or wildlife species occurs prior to the maturation and release of spores, the capacity for sexual reproduction of affected plants may be compromised.

Non-native plant species may threaten habitat occupied by *Botrychium* species. Non-native plant species can compete with native plant species for resources such as space, nutrients, and water, and can replace them. As a result, the effects of non-native species may be especially serious for native taxa that have extremely small population sizes on the Idaho Panhandle National Forests, such as *B. ascendens, B. crenulatum, B. lineare, B. 'michiganense', B. paradoxum,* and *B. pedunculosum.*

Very little is known about the population ecology of *Botrychium* taxa on the Idaho Panhandle National Forests. In particular, the belowground portion of *Botrychium* lifecycle and the mycorrhizal relationship of these species remain poorly understood. A clearer understanding of the relationship between the *Botrychium* species and their mycorrhizal symbionts will also have considerable practical value. An assessment of the effects of disturbance (i.e., logging, fire, and grazing) on their mycorrhizae will assist managers in ascribing appropriate management protocols. Research is also needed to assess the effect on spore output of different mycorrhizal species and infection levels. Studies on the role of mammals and other potential vectors in the dispersal of spores will assist with the management of *Botrychium* species on the Idaho Panhandle National Forests.

Until more knowledge is acquired on the distribution of this species on the Idaho Panhandle National Forests, any inferences drawn from the known populations with regard to population trend or mycorrhizal relationships will be highly speculative. Revisits are needed annually to obtain population size and flucuation data. See Section 1.7 (Research and Monitoring) for survey suggestions.

Of the eleven *Botrychium* species assessed in this report, the most obvious research priorities on the Idaho Panhandle National Forests are a better understanding of the range and distribution of the species with fewer than five documented occurrences. These include *B. ascendens, B. crenulatum, B. lineare, B. 'michiganense', B. paradoxum,* and *B. pedunculosum.*

1.6 Past and Current Conservation Activities

Known populations of sensitive *Botrychium* species are protected under the Idaho Panhandle National Forests Forest Plan. Forest botany personnel and contractors perform on-the-ground clearance surveys in areas of suitable habitat and in areas of known populations of sensitive *Botrychiums*. Populations of *Botrychium* found during these surveys are protected by buffers of restricted use prior to project implementation on the Idaho Panhandle National Forests. The Idaho Panhandle National Forests Forest Plan management goal is to "manage habitat to maintain populations of identified sensitive species of animals and plants" (USFS, 1987 Forest Plan II-1). The Forest Plan standard for sensitive species is to "manage the habitat of species listed in the Regional Sensitive Species List to prevent further declines in populations which could lead to Federal listing under the

"Endangered Species Act" (USFS, 1987 Forest Plan, II-#28). The Forest Plan also identifies the need to "Determine the status and distribution of Threatened, Endangered and Rare (sensitive) plants on the Idaho Panhandle National Forests" (USFS, 1987 Forest Plan, II-#18).

Many of the 11 *Botrychium* species have been identified in riparian areas on the Idaho Panhandle National Forests. The Inland Native Fish Strategy (INFS) establishes goals and guidelines to maintain or restore water quality, riparian areas and associated fish habitats. Interim Riparian Habitat Conservation Areas (RHCAs) were established for all perennial and intermittent streams to achieve riparian management goals and objectives. These areas are protected from many of the management activities of the Idaho Panhandle National Forests and may also protect *Botrychium* species found in designated RHCAs on the Idaho Panhandle National Forests.

1.7 Research and Monitoring

1.7.1 Previous Surveys and Survey Protocol

Prior to 1988, the Idaho Panhandle National Forests did not conduct surveys, and rare plant observations reported to the ICDC were incidental. From 1988 until 1993, approximately 5,000 acres of National Forest lands were surveyed for rare plants. From 1994 to 2002, surveys occurred on 72,531 acres of federal lands with the express purpose of documenting and protecting rare plant populations from management activities and mitigating potential adverse effects.

Chris Lorain conducted surveys for *Botrychium* on the Idaho Panhandle National Forests in 1990. Those findings are documented in Field Investigations of *Botrychium* Subgenus *Botrychium* (Moonwort) on the Idaho Panhandle National Forests (Lorain 1990). The surveys were conducted in order to relocate known populations and historical collection sites of moonworts in northern Idaho and survey for potential habitats and new populations of moonworts on the Idaho Panhandle National Forests.

In 2002, Forest botany personnel and contractors performed on-the-ground clearance surveys on 6,773 acres of high potential habitats for Threatened and Endangered Species and rare plants in support of various projects including timber, watershed, fisheries, Rrecreation, trails, grazing, special uses, and land exchange projects. This also includes a small amount of landscape level surveys not associated with any project. These landscape level surveys are especially important to understanding the distribution of species as they generally occur in remote areas that have a very high potential to support populations (e.g. old growth cedar groves, remote peatlands, Research Natural Areas). Often these areas likely will not have projects in the future that would require surveys. Recent estimates of sensitive plant habitat have determined that approximately 705,000 acres (approximately 28 percent) of the total land base of the Idaho Panhandle National Forests have the potential to support sensitive plant species in a wide array of plant communities. To date, about ten percent of all suitable sensitive plant habitat has been surveyed.

ICDC and USFS botanists have installed some formal, permanent monitoring plots over the last ten years, and baseline information has been collected (1998 Forest Plan Monitoring Report). However, only a few of the formal monitoring plots have been repeatedly measured over multiple years to evaluate population trends. These plots are not surveyed specifically for *Botrychium* species, but if *Botrychium* is found, it is recorded. However, informal monitoring for *Botrychium* species over the last ten years has been conducted on the St. Joe Ranger District of the Idaho Panhandle National Forests (DiGiacomo 2004 pers. comm.).

Since 1991, intuitive-controlled, project-specific surveys for moonworts have been conducted on the Idaho Panhandle National Forests (Goodnow 2004 pers. comm.). During project planning, qualified botanists assess habitats for their suitability to support sensitive and rare plants using U.S. Geological Survey (USGS) maps,

National Wetland Inventory (NWI) maps, USFS Timber Stand Management Record System (TSMRS) data records, and their knowledge of the forest. Habitat found to be suitable within project areas, and which would be affected by project-related activities, is surveyed to determine the presence of rare plant species. Protection measures such as restrictive buffers are implemented to maintain population and species viability following the National Forest Management Act and Forest Service policy.

Another measure of the status and distribution of *Botrychium* in north Idaho is the number of occurrences documented for the five northern counties of Idaho. Information is compiled from the Idaho Conservation Data Center (ICDC 2004a), which is the repository of all information relating to rare species in the State. As of 2004, there are 186 EOs of the eleven moonwort species assessed in this report. However, there are some occurrences that are on file with the Idaho Panhandle National Forests but are not in the ICDC database.

1.7.2 Survey Suggestions

Surveys targeting *Botrychium* species on the Idaho Panhandle National Forests are needed. Project clearance surveys are often inadequate because they do not cover downstream riparian habitat that may be subject to indirect effects of management. Due to limitations in time and funding, attempts to search for rare plants involve looking for multiple species in large areas. While this approach has been effective in finding many rare plant occurrences, it may not be effective for *Botrychium* given their small size, inconspicuous appearance, sporadic distribution, prolonged dormancy, and cryptic nature. Because searching for *Botrychium* requires one's full attention, attempts to search for this species are more likely to be successful if the search image is only for *Botrychium* and not for other plant species. Having experts (contractors, agency botanists, or others trained and experienced with searching for *Botrychium* species) conduct searches in appropriate habitat may be the most effective approach to expanding our knowledge of the distribution of this species on the Idaho Panhandle National Forests.

Several survey methods have been suggested for *Botrychium*. The National Forest Service is currently writing a *Botrychium* Inventory and Monitoring Protocol (Johnson-Groh 2004 pers. comm.), which should be available in 2005. Survey suggestions from other conservation assessments and *Botrychium* experts including Buell (2001) described a simple method for conducting inventories for *Botrychium* species. A zigzag-shaped survey path was followed by one or more surveyors through appropriate habitat, deviating as necessary to highly suitable habitat when it was observed adjacent to the surveyors' path. Upon detection of moonworts, surveyors searched for more plants in a radial expanding pattern emanating from the first plant found until no more individuals were detected. This approach could be useful in large areas of suitable habitat, while in small areas or when sufficient human resources are available, searching the entire area of suitable habitat at a site may be appropriate. In large potential habitat units, having more than one surveyor is useful.

In the past, experts have had great success in finding populations of *Botrychium* using a search image for habitat that they have developed from years of study and survey work (Anderson and Cariveau 2004). For identifying habitat and finding more populations of *Botrychium*, engaging experts on *Botrychium* to the maximum extent possible will help greatly in expanding our knowledge of this species. Identifying suitable habitat in which to focus searches for *Botrychium* could be aided by modeling habitat based on the physiognomy of known occurrences. Intersecting topography, substrate and vegetation could be used to generate a map of potential sites for *Botrychium*. This would be a valuable tool for guiding future searches. Aerial photography and satellite imagery may also assist with the identification of areas worth searching.

1.7.3 Monitoring

It is very difficult to determine the true population size of any *Botrychium* species due to the high proportion of underground gametophytes and juvenile sporophytes, and due to the high annual variation in the aboveground sporophyte population (Lesica and Steele 1994). Multiple seasons and sampling large populations will be required to detect trends. Annual monitoring of selected populations of *Botrychium* could help to understand its ecology and population trends.

A simple annual census of representative colonies (perhaps ten) that are accessible and in well-defined habitats could provide valuable data inexpensively. Randomized permanent plots in which individuals are tracked by marking or mapping them within each sampling unit could help elucidate issues such as life span, dormancy, recruitment success, and population trends. Adding a photoplot component to this work following recommendations offered in Elzinga et al (1998) could facilitate the tracking of individuals and add valuable qualitative information. Monitoring sites should be selected carefully, and a sufficient number of sites should be selected if the data is intended to detect regional population trends. Accurate mapping with Global Positioning System (GPS) equipment is important for monitoring *Botrychium* because of the difficulty in relocating them, particularly with habitat changes that may occur over time.

To address the hypothetical metapopulation structure of *Botrychium*, one approach might be to select highly suitable but unoccupied sites and to attempt to observe colonization events. In a stable population, colonization rates should roughly equal extinction rates, so this approach might permit additional inference into population trends. A detailed and scientifically rigorous monitoring effort will not be possible with smaller populations. Thus, larger populations must be selected for monitoring.

Anderson and Cariveau (2004) suggest estimating cover and/or abundance of associated species within the plots described above could permit the investigation of interspecific relationships through statistical techniques that might show optimal vegetation density, litter depth and other habitat variables. Understanding environmental constraints on *Botrychium* would facilitate the management of the species. Gathering data on edaphic characteristics (primarily moisture and texture) and associated weather data from the permanent plots described above would permit the analysis of species-environment relationships. Such data gathered carefully at the known populations on the Idaho Panhandle National Forests, and then compared with census data, would provide some basic insight into the causes of the fluctuation in aboveground sporophytes, and would help with hypothesis generation for further studies of the ecology of this species.

2. DESCRIPTIONS OF INDIVIDUAL SPECIES

2.1 Upswept Moonwort (Botrychium ascendens)

2.1.1 Classification and Status

Classification: Refer to Section 1.1 (Nomenclature and Taxonomy).
Status: Refer to Appendix A.

2.1.2 Description

Refer to Appendices B and C.

2.1.3 Distribution and Abundance

This species is known from Alberta, British Columbia, Ontario, Yukon Territory, Alaska, California, Montana, Nevada, Oregon, Wyoming, Idaho and Washington (ICDC 2004b). In Idaho, this species is known from the Kootenai River and Moyie River drainages in Boundary County and near Lake Pend Oreille in Bonner County.

In Idaho, there are currently five occurrences of *B. ascendens*, four of which have been found on the Idaho Panhandle National Forests. Element Occurrence Number (EO) #3 is located near the counfluence of Trout Creek and the Kootenai River, EO #4 is located west of the Moyie River and southwest of Bussard Lake, and EO #5 is located north of Bonners Ferry and east of Deer Park. The fourth occurrence is not documented in the ICDC database, but is located on the Idaho Panhandle National Forests, St. Joe Ranger District and is on-file at the district (DiGiacomo 2004 pers. comm.). EO #2 is located on private property, outside the Idaho Panhandle National Forests boundary, west of Lake Pend Oreille and southeast of Gamlin Lake. There is no EO #1 in the ICDC database. Refer to Appendix E for the EO data table and Appendix F for the maps displaying occurrences on the Idaho Panhandle National Forests.

2.1.4 Habitat

Botrychium ascendens is most abundant in the Wallowa Mountains of Oregon where it grows in mesic to moist meadows in the Engleman spruce (*Picea engelmannii*) zone (Wagner and Wagner 1986, Zika 1992, 1994). In Idaho and Washington, it is reported from western redcedar (*Thuja plicata*), subalpine fir (*Abies lasiocarpa*), and alpine meadow habitats (Vanderhorst, 1997).

On the Idaho Panhandle National Forests, this species is documented in moist, western redcedar forests, riparian areas, grassy fields, and moist meadows from 2,120 to 4,600 feet in elevation (ICDC, 2004b). One site aspect has been documented as southeast (EO #4), but the other sites did not cite information on aspect. Slopes are documented from two percent (EO #5), 33 percent (EO #4), and 15 percent (St. Joe site).

EO #3 is documented along Trout Creek, one mile from the confluence of Trout Creek and Kootenai River in *Thuja plicata* (western redcedar) overstory with *Carex* sp. (sedges) ground cover. EO #4 is documented in a small draw within the floodplain of a creek. The area is well-shaded and appears to be seasonally wet. The vegetation consists of *Thuja plicata/Clintonia uniflora/Aralia nudicaulis* (western redcedar/Queen's cup bead lily/ wild sarsaparilla) plant community dominated by tree and shrub species consisting of *Thuja plicata*, *Betula papyrifera* (western paper birch), *Populus trichocarpa* (black cottonwood), and *Alnus incana* (grey thinleaf alder). Herb vegetation consists of *Aralia nudicaulis*, *Botrychium virginianum* (rattlesnake fern), *Clintonia uniflora*, *Fragaria vesca* (wild strawberry), *Galium trifidum* (threepetal bedstraw), and *Viola adunca* (early blue violet).

EO #5 is documented in a moist area consisting of *Thuja plicata/Clintonia uniflora/ Clintonia uniflora* (western redcedar/Queen's cup bead lily/ Queen's cup bead lily) habitat type. The tree vegetation consists of *Thuja plicata, Betula papyrifera, Populus trichocarpa, Abies grandis* (grand fir) and *Acer glabrum* (rocky mountain maple). Herb vegetation consists of moss, *Aralia nudicaulis*, *Linnaea borealis* (twinflower), *Clintonia*, *Athyrium filix-femina* (lady fern), *Maianthemum stellatum* (starry false lily of the valley), *Symphoricarpos albus* (western snowberry), *Rosa* sp. (Rose species), *Rubus parviflorus* (thimbleberry), and *Fragaria virginiana* (Virginia strawberry).

The fifth occurrence (EO#5) of *B. ascendens* is located on the St. Joe Ranger District near Simmons Creek in a wet forested area groveallocated as old growth. Although an allocated old growth designation provides some measure of protection, these areas are technically still available for potential timber harvest (DiGiacomo, 2004, pers. comm.). Associated species includes *Thuja plicata*, *Menziesia ferruginea* (Fool's huckleberry), *Vaccinium*

globulare (globe huckleberry), *Athyrium filix-femina, Gymnocarpium dryopteris* (western oakfern), *Clintonia uniflora,* and *Asarum caudatum*.

2.1.5 Population Biology and Viability

On the Idaho Panhandle National Forests, the *Botrychium ascendens* sites have relatively dense cover by trees, shrubs, herbs, and moss species. Most population numbers documented are very small, indicating only one plant at EO #3, 4, 5. Population vigor is assessed as poor at these locations. The St. Joe site includes 30 plants and plant vigor is assessed as good. No evidence of herbivory is documented; however, the now obliterated Forest Road #1278 was built through the St. Joe population.

2.1.6 Summary of Land Ownership and Existing Habitat Protection

In Idaho, one occurrence is located on private land outside the Idaho Panhandle National Forests. Three sites are located on the Bonners Ferry District and one is located on the St. Joe District of the Idaho Panhandle National Forests adjacent to riparian areas that should be protected by INFS and RHCAs, discussed in Section 1.6. The St. Joe population is in allocated old growth.

2.1.7 Current or Potential Threats to Habitat and Management Activities

All known populations on the Idaho Panhandle National Forests, are located on lands allocated for timber harvest (MAs 1, 3, and 4), and the Idaho Panhandle National Forests should consider proposals of management activities in the occurrence drainages. The St. Joe District population site is in a cedar stand allocated as old growth, and timber harvest is unlikely to occur. The site has been affected by unauthorized ATV use (DiGiacomo, 2004, pers. comm.).

Because of its low numbers and occurrence in dynamic riparian and moist habitats, *Botrychium ascendens* is vulnerable to extirpation on the Idaho Panhandle National Forests. Timber harvest and other habitat-altering activities such as road building or drainage of swampy habitats pose the most significant threats to upswept moonwort. Because of the low occurrence numbers, conservation management for *Botrychium ascendens* should be a high priority for the sensitive plant program on the Idaho Panhandle National Forests (refer to Section 1.5).

2.1.8 Past and Current Conservation Activities

The St. Joe site is protected in a stand allocated as old growth. Refer to Section 1.6.

2.1.9 Research and Monitoring

Refer to Section 1.7.

2.2 Dainty Moonwort (Botrychium crenulatum)

2.2.1 Classification and Status

Classification: Refer to Section 1.1 (Nomenclature and Taxonomy).
Status: Refer to Appendix A.

2.2.2 Description

Refer to Appendices B and C.

2.2.3 Distribution and Abundance

B. crenulatum is very rare and local, but exhibits a rather extensive range. It is known to occur from Oregon to Utah and as far north as Montana and Alberta (Wagner and Devine 1989). This species is known from three occurrences in Idaho. One is located in northeastern Kootenai County (EO #3) on the Idaho Panhandle National Forests. There are also two historical collections. One is from north of Naples in Boundary County (EO #1) on the Idaho Panhandle National Forests and the other is from north of Pierce in Idaho County (EO #2) on the Clearwater National Forest (ICDC 2004a). The two historical sites have been tentatively identified as *B. crenulatum* from herbarium specimens at Washington State University, Pullman, Washington. The Boundary County site (EO #1) was not relocated during the 1990 inventory survey on the Idaho Panhandle National Forests (Lorain 1990) and is represented as a larger area on the EO Data Maps (Appendix F) because the exact site location is not known. Refer to Appendix E for the EO data table and Appendix F for the maps displaying occurrences on the Idaho Panhandle National Forests.

2.2.4 Habitat

Dainty moonwort principally grows at low elevations in drier microsites of damp meadows, boggy areas, and marshes, either on hillsides or flat lands where there are wet banks or springy spots (Wagner and Wagner 1981, Lellinger 1985). The plants are generally rooted in tussocks or "rises" around isolated trees or shrubs, in depressions that dry out during the summer, or at the edges of marshes. In California, plants have also been found on creek banks, clearings, and in mixed conifer forests growing in more or less damp soil under sedges or on organic, mossy soil. They may occur either in sun or shade, but evidently prefer partial shade (Wagner and Wagner 1981, Wagner and Devine 1989). Throughout its range, *B. crenulatum* is known to grow with the other moonworts *B. ascendens, B. lunaria* (common moonwort), *B. minganense* (Mingan moonwort), and *B. simplex* (least moonwort) (Wagner and Wagner 1993). In Montana, the habitats of *Botrychium crenulatum* include wetlands dominated by native trees and shrubs and wet roadsides dominated by herbaceous exotic species.

On the Idaho Panhandle National Forests, this species occurs at elevations ranging from 2,100 to 3,720 feet. The historic site (EO #1) occurred in deep duff dominated by *Thuja plicata* habitat. The Kootenai County site (EO #3) on the Idaho Panhandle National Forests was observed in a moist meadow adjacent to Big Elk Creek in a dispersed campground, in an open canopy on a northeastern aspect with no slope. The surrounding vegetation on this site consists of tree, shrub and forb species such as *Abies grandis* (grand fir), *Abies lasiocarpa* (alpine fir), *Pinus monticola* (western white pine), *Englemann spruce, Tsuga heterophylla* (western hemlock), *Elymus* sp. (rye sp.), *Trifolium* sp. (clover sp.), *Phalaris* sp. (reed sp.), *Salix* sp. (willow sp.), *Fragaria* sp*., Sorbus* sp*.* (ash sp.), *Arnica* sp. (arnica sp.), *B. lanceolatum* (triangle moonwort), and *B. pinnatum* (northwestern moonwort). *B. crenulatum* was also observed growing with *B. lanceolatum* and *B. pinnatum* at EO #3.

2.2.5 Population Biology and Viability

The historic documentation (EO #1) on the Idaho Panhandle National Forests did not provide population information. The Kootenai County site (EO #3) on the Idaho Panhandle National Forests consisted of approximately 20 fronds with 30 to 40 genets, 95 percent mature and five percent senescent.

2.2.6 Summary of Land Ownership and Existing Habitat Protection

The historical collection from Boundary County (EO #1) is located on the Bonners Ferry District of the Idaho Panhandle National Forests and is represented as a larger area on the EO Data Maps (Appendix F) because the exact location is not known. The Idaho County collection (EO #2) is on the Clearwater National Forest. The Kootenai County site (EO #3) is located on the Coeur d'Alene River Ranger District of the Idaho Panhandle National Forests.

2.2.7 Current or Potential Threats to Habitat and Management Activities

On the Idaho Panhandle National Forests, the Kootenai County site (EO #3) was observed adjacent to Big Elk Creek in a dispersed campground. This area is also allocated for timber production in MA1. Habitat-altering activities such as logging, trampling from recreation or road building pose the most significant threats to dainty moonwort in this location.

On the Idaho Panhandle National Forests, only one site is reported with habitat information (EO #3). The historic site (EO #1) on the Idaho Panhandle National Forests is represented by incomplete habitat information. Therefore, priority for conservation management of this species on the Idaho Panhandle National Forests should be protection of the Kootenai County known population (EO #3) in the dispersed campground, verification of the historic sighting (EO #1) of *Botrychium crenulatum*, and a more detailed field report of habitat for all sites. In addition, a separate conservation strategy may be required for this species (refer to Section 1.5).

2.2.8 Past and Current Conservation Activities

Refer to Section 1.6.

2.2.9 Research and Monitoring

Refer to Section 1.7.

2.3 Triangle Moonwort (*Botrychium lanceolatum*)

2.3.1 Classification and Status

Classification: Refer to Section 1.1 (Nomenclature and Taxonomy).
Status: Refer to Appendix A.

2.3.2 Description

Refer to Appendices B and C.

2.3.3 Distribution and Abundance

Triangle moonwort is rare and local but exhibits a rather extensive range. It is known to occur from Newfoundland east to Minnesota, and south to Virginia and Tennessee; from Tennessee northwest to Minnesota; from Alaska to Oregon, Idaho and Montana and at higher elevations in Colorado, Utah, New Mexico, and Arizona (ICDC 2004b).

Fifty-eight sites of triangle moonwort are currently documented for Idaho: 53 are located within the Idaho Panhandle National Forests and five of the sites (EO#10, 12, 21, 42, and 56) are located outside the Idaho Panhandle National Forests boundaries. Several sites (EO#7, 16, 18, 45, and 48) are represented by more than one point on the EO data map. Refer to Appendix E for the EO data table and Appendix F for the map displaying occurrences on the Idaho Panhandle National Forests.

Norm Trigoboff first recorded *Botrychium lanceolatum* in Boundary County near Spread Creek (EO #2) in 1987 during a field survey on the Idaho Panhandle National Forests (Caicco 1987). In 1989, Robert Moseley discovered another population during a survey by the Idaho Natural Heritage Program in northern Idaho (EO #1). A collection was made from this second site and is deposited in the University of Idaho Herbarium. During the 1990 survey conducted by C. Lorain on the Idaho Panhandle National Forests, the Moseley collection was relocated and two new sites (EO #3 and EO #4) were discovered for triangle moonwort (Lorain, 1990).

Since the 1990 survey, 54 additional sites have been discovered in Idaho. Several sites are represented by more than one point on the EO data map. Refer to Appendix E for the EO data table and Appendix F for the map displaying occurrences on the Idaho Panhandle National Forests.

2.3.4 Habitat

Triangle moonwort grows in a wide variety of habitats including wet to moist grassy and rocky slopes, meadows, woods, roadsides, and edges of lakes generally at fairly high elevations (Wagner and Wagner 1983, Lellinger 1985). Soils tend to be cold and mostly subacid in nature. On the Idaho Panhandle National Forests, most of the documented sites are associated with a draw or riparian area. However, plants have been documented from open riparian meadows, shaded western redcedar forest floor, small fern opening along a road, old growth forest, and a dry lodgepole meadow. Elevations of the recorded sites are between approximately 2,400 and 4,800 feet.

Habitat types associated with Triangle moonwort on the Idaho Panhandle National Forests include the following:

- *Abies lasiocarpa* (subalpine fir) habitat type
- *Abies lasiocarpa/Clintonia uniflora* (subalpine fir/queen's cup beadlily) habitat type
- *Abies lasiocarpa/ Xerophyllum tenax* (subalpine fir/beargrass) habitat type
- *Pinus contorta* (lodgepole pine) habitat type
- *Picea engelmannii/Abies lasiocarpa* (Engelmann spruce/ subalpine fir) habitat type
- *Thuja plicata/Asarum caudatum* (western redcedar/wild ginger) habitat type
- *Thuja plicata/Athyrium filix-femina* (western redcedar/lady-fern) habitat type
- *Thuja plicata/Gymnocarpium dryopteris* (western redcedar/oakfern) habitat type
- *Thuja plicata/Oplopanax horridum* (western redcedar / devil's club) habitat type
- *Tsuga heterophylla/Clintonia uniflora* (western hemlock/ queen's cup beadlily) habitat type
- *Tsuga heterophylla/Gymnocarpium dryopteris* (western hemlock/ western oakfern) habitat type

Species found growing with triangle moonwort include a vast array of tree, shrub and forb species. Tree species include *Abies grandis, Abies lasiocarpa, Picea engelmannii, Pinus contorta, Pinus monticola, Larix occidentalis* (western larch), *Populus trichocarpa, Taxus brevifolia* (pacific yew), *Thuja plicata,* and *Tsuga heterophylla*.

Shrub species include *Acer glabrum* (rocky mountain maple), *Alnus incana, Alnus sinuata* (sitka alder), *Amelanchier alnifolia* (western serviceberry), *Cornus sericea* (red stem dogwood), *Crataegus douglasii* (black hawthorne), *Fragaria vesca, Fragaria virginiana, Pachistima myrsinites* (Oregon boxwood), *Ribes lacustre* (prickly currant), *Rosa gymnocarpa* (wood rose), *Rubus leucodermis* (western raspberry), *Rubus parviflorus*, *Rubus pedatus* (strawberryleaf raspberry), *Rubus pubescens* (dwarf red blackberry), *Salix scouleriana* (Scouler's willow), *Sambucus racemosa* (red elderberry), *Spiraea densiflora* (subalpine spirea), *Spiraea douglasii* (Douglas spirea), *Spiraea betulifolia* (white spirea), *Symphoricarpos albus* (western snowberry), *Vaccinium globulare* (globe huckleberry), *Vaccinium myrtillus* (whortleberry), and *Vaccinium scoparium* (grouse whortleberry).

Forbs, ferns, fern allies, sedges, and grasses species include the following:

- *Achillea millefolium* (common yarrow)
- *Aconitum columbianum* (Columbian monkshood)
- *Actaea rubra* (baneberry)
- *Adenocaulon bicolor* (American trailplant)
- *Adiantum pedatum* (maidenhair fern)
- *Agrostis oregonensis* (Oregon bentgrass)
- *Agrostis scabra* (rough bentgrass)
- *Agrostis stolonifera* (creeping bentgrass)
- *Agrostis tenuis* (colonial bentgrass)
- *Agrostis thurberiana* (thurbur bentgrass)

- *Anaphalis margaritacea* (pearly everlasting)
- *Angelica arguta* (white angelica)
- *Angelica dawsonii* (Dawson's angelica)
- *Antennaria luzuloides* (rush pussytoes)
- *Aralia nudicaulis* (wild sarsaparilla)
- *Arctostaphylos uva-ursi* (kinnikinnick)
- *Arnica cordifolia* (heartleaf arnica)
- *Asarum caudatum* (wild ginger)
- *Aster campestris* (western meadow aster)
- *Aster foliaceus* (alpine leafybract aster)
- *Athyrium filix-femina* (lady fern)
- *B. crenulatum*
- *B. minganense*
- *B. montanum*
- *B. multifidum* (leathery grapefern)
- *B. pinnatum*
- *B. virginianum* (rattlesnake fern)
- *Boykinia major* (meadow boykinia)
- *Bromus marginatus* (mountain brome)
- *Bromus vulgaris* (Columbia brome)
- *Calamagrostis canadensis* (bluejoint reedgrass)
- *Calamagrostis rubescens* (pinegrass)
- *Campanula parryi* (Parry's bellflower)
- *Campanula rotundifolia* (bluebell bellflower)
- *Carex crawfordii* (Crawford's sedge)
- *Carex deweyana* (Dewey sedge)
- *Carex geyeri* (elk sedge)
- *Carex microptera* (alpine blackheaded sedge)
- *Castelleja angustifolia* (NW indian-paintbrush)
- *Centaurea maculosa* (spotted knapweed)
- *Chimaphila menziesii* (little prince's pine)
- *Chimaphila umbellata* (pipsissewa)
- *Cinna latifolia* (northern wood-reed)
- *Circaea alpina* (small enchanter's nightshade)
- *Coptis occidentalis* (Idaho goldthread)
- *Cirsium scariosum* (meadow thistle)
- *Clintonia uniflora* (queen's cup beadlily)
- *Cornus canadensis* (bunchberry dogwood)
- *Dactylis glomerata* (orchard grass)
- *Danthonia intermedia* (timber oatgrass)
- *Dicentra uniflora* (longhorn steershead)
- *Disporum hookeri* (Hooker's fairy-bells)
- *Dryopteris austriaca* (wood fern)
- *Dryopteris expansa* (northern wood fern)
- *Dryopteris filix-mas* (male fern)
- *Elymus glaucus* (blue wildrye)
- *Epilobium anagallidifolium* (alpine willow herb)
- *Epilobium angustifolium* (rosebay willow herb)
- *Festuca subulata* (bearded fescue)
- *Galium trifidum* (threepetal bedstraw)
- *Galium triflorum* (fragrant bedstraw)
- *Geum macrophyllum* (large-leaf avens)
- *Goodyera oblongifolia* (western rattlesnake plantain)
- *Gymnocarpium dryopteris* (western oakfern)
- *Heracleum maximum* (cow parsnip)
- *Heuchera cylindrica* (greenfinch)
- *Hypericum perforatum* (common St. Johnswort)
- *Lathyrus nevadensis* (mountain pea)
- *Ligusticum canbyi* (Canby's licorice-root)
- *Linnaea borealis* (twinflower)
- *Listera cordata* (heart-leaved twayblade)
- *Lonicera involucrata* (black twinberry)
- *Luzula campestris* (field woodrush)
- *Luzula divaricata* (forked woodrush)
- *Maianthemum stellatum* (starry Solomon's seal)
- *Melica subulata* (Alaska oniongrass)
- *Menziesia ferruginea* (fool's huckleberry)
- *Mertensia paniculata* (tall bluebells)
- *Mitella caulescens* (slightstemmed miterwort)
- *Montia cordifolia* (heartleaf springbeauty)
- *Moneses uniflora* (one-flowered wintergreen)
- *Oplopanax horridum* (devil's club)
- *Osmorhiza purpurea* (purple sweetroot)
- *Osmorhiza berteroi* (mountain sweet cicely)
- *Pentstemon confertus* (yellow penstemon)
- *Phleum pratense* (timothy)
- *Poa pratensis* (Kentucky bluegrass)
- *Poa scabrella* (pine bluegrass)
- *Polemonium occidentale* (western polemonium)
- *Polystichum munitum* (western swordfern)
- *Potentilla gracilis* (graceful cinquefoil)
- *Prunella vulgaris* (common selfheal)
- *Prunus emarginata* (bitter cherry)
- *Pteridium aguilinum* (bracken fern)
- *Pyrola asarifolia* (liverleaf wintergreen)
- *Ranunculus occidentalis* (western buttercup)
- *Ranunculus repens* (creeping buttercup)

- *Ranunculus uncinatus* (woodland buttercup)
- *Salix melina* (western coneflower)
- *Senecio integerrimus* (lambstongue ragwort)
- *Senecio triangularis* (arrowleaf ragwort)
- *Solidago ca*nadensis (Canada goldenrod)
- *Stellaria media* (common chickweed)
- *Streptopus amplexifolius* (claspleaf twistedstalk)
- *Streptopus streptopoides* (small twistedstalk)
- *Tellima grandiflora* (fringe cup)
- *Thalictrum occidentale* (western meadow-rue)
- *Tiarella trifoliata* (foamflower)
- *Tiarella unifoliata* (one leaf foam flower)
- *Trautvetteria carloinensis* (Carolina bugbane)
- *Trifolium agrarium* (palmate hop clover)
- *Trillium ovatum* (western trillium)
- *Trisetum spicatum* (spike trisetum)
- *Veratrum californicum* (California false hellebore)
- *Veratrum viride* (green false hellebore)
- *Veronica chamaedrys* (Germander speedwell)
- *Veronica serpyllifolia* (thymeleaf speedwell)
- *Viola adunca* (early blue violet)
- *Viola glabella* (stream violet)
- *Viola orbiculata* (round-leaf violet)
- *Woodsia oregana* (Oregon cliff fern)

2.3.5 Population Biology and Viability

There are 53 documented sites of *Botrychium lanceolatum* documented on the Idaho Panhandle National Forests. Population estimates for a majority of the sites (37 sites or 70 percent of the total) were relatively small and contained only one to 10 plants. Eight of the sites (15 percent) contained 50 to 100 plants. The majority of the larger sites (approximately 50 to 150 individuals) of *B. lanceolatum* occur near riparian or wet habitat areas such as Smith Creek (EO #3), Big Elk Creek (EO #11), Shoshone Creek (EO #46), a draw bottom near Jeru Peak (EO #48), a draw bottom north of Larch Mountain (EO #51), and Ruby Creek (EO #58). However, two of the larger populations (EO #1 and EO #13) occur in upland habitat.

Many species of *Botrychium* are associated with light to moderate disturbances (Lellinger 1985, Wagner and Wagner 1993). Reports for *B. lanceolatum* habitat usually indicate forested environments with a less active disturbance regime. The species is apparently tolerant of, but not dependent on, some level of disturbance (USFS 1999).

According to the EO Data, most of the sites (approximately 87 percent) on the Idaho Panhandle National Forests were found associated with small draws and riparian areas and occurred and on a north to northeastern aspect. The canopy closures and slopes at the documented sites varied from 0 to 100 percent.

Other *Botrychium* species that occur within habitat occupied by *B. lanceolatum* (ICDC 2004a) included *B. crenulatum, B. minganense, B. montanum, B. multifidum, B. pinnatum,* and *B. virginianum,* but the data did not show a preference of a particular species of *Botrychium* growing with *B. lanceloatum* at multiple sites.

2.3.6 Summary of Land Ownership and Existing Habitat Protection

Of the 58 documented locations of triangle moonwort in North Idaho, 53 are located on Idaho Panhandle National Forests. Several of the sites (EO#7, 16, 18, 45, and 48) are represented by more than one point on the EO map in Appendix F. Seven sites are located on the Sandpoint Ranger District, 11 sites are on the CDA River Ranger District, 12 are on the Bonners Ferry Ranger District, and 23 are on the Priest Lake Ranger District.

Three of the sites (EO #1, 36, and 53) are located on MA 9, where no scheduled harvests occur. EO #30 is located within MA1, but is in the Hanna Flats Cedar Grove Botanical Area, allocated old growth, and is protected

from logging. EO #49 is located within MA13, a special interest area, the thoroughfare of Priest Lake, and is also protected from logging.

2.3.7 Current or Potential Threats to Habitat and Management Activities

According to the EO Data, most of the sites (90 percent) are located on lands allocated for timber production. Nine of the sites (EO #13,15, 25, 27, 30, 34, 36, 50, 54) or 17 percent are located in "mature" or "old growth" forest habitat. Three of the sites (EO #14, 2, 31) or six percent are found in association with mossy areas. Sixteen of the sites (EO #1, 2, 3, 8, 14, 15, 16, 18, 19, 22, 31, 32, 33, 38, 53, and 58) or 30 percent occur near a trail or roadside. Three of the sites (EO #4, 31, 34) or six percent occur in or near developed and/or undeveloped campsites. Twenty sites (38 percent) were described in riparian habitat. EO #33 occurs adjacent to a clear cut areas and (EO #50) is located in a fire-generated immature stand. EO #30 is within old growth allocated area within MA1 (Hanna Flats Cedar Grove Botanical Area) and is protected from logging. EO #49 is in the Upper Priest Lake Scenic Area and is also protected from logging.

Because the documented sites are located in so many different habitats on the Idaho Panhandle National Forests, habitat-altering activities such as logging, road building, grazing, and trampling (by human, elk, deer, and/or cattle) may impact potential habitat. Road stream and draw crossings and log decks are often located along low gradient reaches where *B. lanceolatum* is most likely to be found. Refer to Section 1.5.

2.3.8 Past and Current Conservation Activities

Three of the sites (EO #1, 36, and 53) are located in MA 9, where no scheduled harvests occur. EO #30 is in a botanical area within MA1- Hanna Flats Cedar Grove Botanical Area - and is protected from logging. EO #49 is in the Upper Priest Lake Scenic Area and is also protected from logging. Refer to Section 1.6.

2.3.9 Research and Monitoring

Refer to Section 1.7.

2.4 Slender Moonwort (Botrychium lineare)

2.4.1 Classification and Status

Classification: Refer to Section 1.1 (Nomenclature and Taxonomy).
Status: Refer to Appendix A. This species is a candidate for Federal listing under the Endangered Species Act.

2.4.2 Description

Refer to Appendices B and C.

2.4.3 Distribution and Abundance

In the United States, *Botrychium lineare* is currently known from a total of nine populations: three in Colorado (El Paso and Lake Counties), two in Oregon (Wallowa County), three in Montana (Glacier County), one in Washington (Ferry County) (USFWS 2000, Oregon Natural Heritage Program, 1999). Surveys conducted in 2001 identified two new *Botrychium lineare* populations in Idaho (Sawtooth Mountains) and Nevada on the basis of their plant morphology, although Farrar (2004 pers. comm.) stated that their identity should be verified by enzyme electrophoresis. In addition to the nine currently known populations, there are four historic *B. lineare* population sites in the United States and two in Canada (USFWS 2000).

In Idaho, this species is known from a single historical sighting (EO #1) collected in 1925 by C. Epling in the Upper Priest River in Boundary County on the Idaho Panhandle National Forests (ICDC 2004a). An attempt was made to relocate this site during a *Botrychium* workshop conducted in 2001 (Farrar 2004 pers. comm.). The area was thoroughly searched but no *Botrychium* species were found and the site did not appear to be appropriate habitat for the species. The site appeared to have been burned in the 1920s or 1930s, based on the age of the current stand of trees (Hammet 2004 pers. comm). The site is represented as a large area on the EO Data Map (Appendix F) because the exact location is not known. Refer to Appendix E for the EO data table and Appendix F for the maps displaying occurrences on the Idaho Panhandle National Forests.

2.4.4 Habitat

Because the single historic documentation on the Idaho Panhandle National Forests (EO #1) does not provide habitat information, known habitat from other northwestern states and Canada is described in this section. The single historic documentation on the Idaho Panhandle National Forests (EO #1) did not specify habitat or the presence of companion species, only that *B. lineare* was found in "shaded woods; sandy soil" at 3,000 feet elevation.

The habitat for *Botrychium lineare* has been described as "deep grass and forbs of meadows, under trees in woods, and on shelves on limestone cliffs, mainly at higher elevations" (Wagner and Wagner 1994). Typical habitat for this species would be problematic since the known sites range from sea level in Quebec to nearly 9,840 ft in Boulder County, Colorado. This species is found in a variety of montane forest or meadow habitats. Three of the known Montana *Botrychium lineare* populations occur on roadsides in early serial habitat (USFWS 2000).

Other *B. lineare* sites occur in grass-to forb-dominated openings in forests characterized by cone-bearing trees such as pine, spruce, and fir species (USFWS 2000). At these occupied sites, *B. lineare* occurs with associated species including *Fragaria virginiana*, *Antennaria spp.* (pussy-toes), *Galium boreale* (northern bedstraw), *Potentilla spp.* (cinquefoil), *Symphoricarpos albus* (snowberry), *Vaccinium spp.* (huckleberry), *Calamagrostis spp.* (reedgrass), *Festuca spp.* (fescue), *Picea engelmannii, Thuja plicata, Pseudotsuga menziesii, Pinus ponderosa* (ponderosa pine), *Pinus contorta*, and *Populus tremuloides* (quaking aspen) (USFWS 2000). Other *Botrychium* species, including *B. ascendens, B. crenulatum, B. minganense, B. lunaria,* and *B. montanum* may also occur within or near habitat occupied by *B. lineare* (USFWS 2000).

2.4.5 Population Biology and Viability

The EO data on the single historic observation (EO #1) on the Idaho Panhandle National Forests did not disclose information on population biology and viability. The total number of individuals for all nine occupied sites in the U.S. is about 190 (USFWS, 2000). However, this number should be viewed as an estimate since *Botrychium* species do not always come up every year and exist below ground for most of their life cycle. Populations range in size from two to 100 individuals. Only three populations contain more than 15 individuals (USFWS 2000). The small size of existing known *Botrychium lineare* populations makes this species vulnerable to extirpation due to random naturally occurring events. A single random event could extirpate a substantial portion or all of the individuals at a given site (USFWS, 2000).

Botrychium lineare was initially described in 1994 and is considered to be one of the more distinctive of the moonworts (Wagner and Wagner 1994). The nearest relative of *B. lineare* is thought to be *B. campestre*, a widespread species that is typically found at lower elevations (Wagner and Wagner 1994). Recent genetic studies have shown that although *B. lineare* is closely related to *B. campestre*, it is a distinct taxon (USFWS 2000). A tetraploid hybrid of *B. lineare* and *B. campestre* has been documented from the Sawtooth Mountains in southern Idaho (Farrar 2004 pers. comm.) The *B. lineare* populations in Colorado, Oregon, Montana, and Washington are all genetically distinct from one another, which suggests a long period of isolation that is consistent with truly rare species (USFWS, 2000).

2.4.6 Summary of Land Ownership and Existing Habitat Protection

In Idaho, the historical sighting documented and collected by C. Epling in the Upper Priest River is located on the Idaho Panhandle National Forests (ICDC, 2004a). This site is located on Idaho Panhandle National Forests land allocated for timber production in MA3.

Of the three largest populations in the U.S., two are found in Montana (Glacier National Park and Blackfeet Indian Reservation) and one occurs in Colorado (Pikes-San Isabel National Forest) (USFWS, 2000). Of the remaining six *B. lineare* populations, four occur on Federal land, including the Pike-San Isabel National Forest (Colorado), Glacier National Park (Montana), Wallowa-Whitman National Forest (Oregon), and Colville National Forest (Washington) (USFWS 2000). One population occurs on private land in Lostine Canyon, Oregon. The *B. lineare* site in Lake County, Colorado, is currently only known from a herbarium specimen consisting of two *B. lineare* plants collected in 1992 (USFWS, 2000).

2.4.7 Current or Potential Threats to Habitat and Management Activities

Only one historic population of *Botrychium lineare* is known on the Idaho Panhandle National Forests and this site has not been relocated. The small amount of occupied habitat and extremely low number of individuals, combined with ongoing threats, make this species vulnerable to extinction. Because of the low occurrence numbers, conservation management for *Botrychium lineare* should be a high priority for the sensitive plant program on the Idaho Panhandle National Forests. The historic site should be relocated and detailed habitat information recorded for the site. The historic site is located on land allocated for timber harvest (MA3) and the Idaho Panhandle National Forests should consider proposals of management activities in Upper Priest River drainage (refer to Section 1.5).

The USFWS concludes that the overall magnitude of threats to *B. lineare* throughout its range is moderate and the overall immediacy of these threats is non-imminent (USFWS 2000). *B. lineare* is a candidate for Federal listing under the Endangered Species Act. USFWS will continue to monitor the status of the slender moonwort. Should an emergency situation develop with this species, The USFWS will act to provide immediate protection, if warranted.

2.4.8 Past and Current Conservation Activities

Refer to Section 1.6

2.4.9 Research and Monitoring

Monitoring helps to identify threats and management actions that may be necessary to control habitat degradation and protect the species. Only one historic site is identified on the Idaho Panhandle National

Forests. However, the site has not been relocated and appears to be in unsuitable habitat (Farrar 2004 pers comm.). Suitable habitat near the proposed site should be searched for *Botrychium lineare* to determine if the sight is in the wrong location or if the species has been extirpated (refer to Section 1.7).

2.5 Michigan Moonwort (Botrychium 'michiganense')

2.5.1 Classification and Status

Classification: *Botrychium 'michiganense'* is the proposed name for the primarily eastern taxon that W.H. Wagner initially called *Botrychium hesperium*. He subsequently decided that these plants were different from true western *Botrychium hersperium* and proposed the name *Botrychium 'michiganense.'*

Status: *B. 'michiganense'* has been placed in a peer review category by ICDC and the Idaho Native Plant Society until a review document is approved and the taxon becomes valid. Peer review was designed to improve the quality of communication and to increase the rigor of the assessment.

Botrychium 'michiganense' is listed as sensitive in Region 9 of the USFS. *Botrychium hesperium* is considered threatened by the state heritage program in Michigan, where it is now recognized to be *B. 'michiganense'*; it is considered sensitive by the state heritage program in Washington. When *B. 'michiganense'* is formally described, many state/province ranks will likely need revision.

2.5.2 Description

There has been some perplexity regarding the recognition of *Botrychium 'michiganense'* as a species. Donald Farrar and colleagues are in the process of publishing a review document that describes *B. 'michiganense'* (Appendix C). A closely related species, *Botrychium hesperium*, is a small fern with a disjunct distribution in the Rocky Mountains and the Upper Great Lakes region. Due to a number of morphological differences in the taxon of the plants in each of these regions, the Great Lakes populations will be separated into *B. 'michiganense'* in the future (Anderson and Cariveau, 2004).

Botrychium lanceolatum is involved in the parentage of *B. 'michiganense'*, but the other parent is unclear (Anderson and Cariveau 2004). Farrar considers the northern plants called *Botrychium 'fenestratum'* and *B. 'venulosum'* to be merely variants within *B. hesperium* (Anderson and Cariveau 2004). *Botrychium 'fenestratum'* is known from Oregon and Washington, while *B. 'venulosum'* has been documented from Montana (Anderson and Cariveau 2004). *B. 'fenestratum'* grades morphologically into *B. hesperium*, and no differences in allozyme patterns are evident between *B. 'fenestratum', B. 'venulosum',* and *B. hesperium* in enzyme electrophoretic analyses (Anderson and Cariveau, 2004).

B. 'michiganense' has several morphological differences from *B. hesperium* that are mentioned in Wagner and Wagner (1990). In general, *B. 'michiganense'* is larger and narrower than *B. hesperium* (Wagner and Wagner, 1990). The pinnae are also more remote and have wedge-shaped bases (Anderson and Cariveau, 2004). The trophophore segments in *B. hesperium* are relatively blunt, while those of *B. 'michiganense'* are sharper. The basal pinnae have a tendency to be strongly enlarged, and the sporophore has three main axes in *B. 'michiganense'* (Wagner and Wagner, 1990). However, this is often true of *B. hesperium* as well and is not as valuable for diagnostic purposes. *Botrychium 'michiganense'* differs genetically from *B. hesperium* (Anderson

and Cariveau, 2004). *Botrychium hesperium* and *B. 'michiganense'* are easily confused with *B. matricariifolium* (Higman and Penskar, 1999). However, the range of *B. hesperium* will no longer overlap with *B. matricariifolium* after *B. 'michiganense'* is described.

2.5.3 Distribution and Abundance

The single occurrence of *Botrychium 'michiganense'* in northern Idaho on the Idaho Panhandle National Forests will not be documented in the ICDC database until the species is formally classified. The siting is displayed on the EO Data Map in Appendix F from a field data form on file with the Idaho Panhandle National Forests, Sandpoint Ranger District. Refer to Appendix E for the EO data table and Appendix F for the maps displaying occurrences on the Idaho Panhandle National Forests.

Plants of *Botrychium 'michiganense'* have been confirmed from Michigan, Minnesota and Ontario in the Lake Superior region, the Black Hills region of eastern Wyoming, northwestern Montana, eastern Washington, Waterton Lakes in Alberta, and the Cypress Hills in Saskatchewan (Farrar 2004). Collections of *B. hesperium* from the northern Rocky Mountains in the US and Canada not examined in this study need to be re-examined for possible misidentification or mixed collections containing *B. 'michiganense'* (Farrar, 2004).
Botrychium 'michiganense' is known from 22 sites: seven in Ontario, five in Michigan, two in Minnesota, one in Wyoming, two in Montana, two in Washington, two in Alberta and one in Saskatchewan (Anderson and Cariveau, 2004). In some of these sites, it occurs in numbers up to 100 or more individuals. It may be under-reported because of taxonomic confusion with other species and lack of publicity regarding its existence (Anderson and Cariveau, 2004). Extensive searches in the Great Lakes area and in the U.S. Rocky Mountains indicate that it is in an uncommon species in these areas. It may prove to be more common in the northern Great Plains of the U.S. and Canada (Anderson and Cariveau, 2004).

2.5.4 Habitat

The single population on the Idaho Panhandle National Forests is located in a weedy clearing surrounded by approximately 20-year old conifers at 2,640 feet. The site is located on an easterly aspect and two percent slope. Associated species included *Pinus contorta, Pinus ponderosa, Pseudotsuga menziesii, Centaurea biebersteinii, Leucanthemum vulgare, Trifolium repens, Trifolium hybridum, Hieraceum auantiacum, Hypericum perforatum, Centaurea maculosa,* and *Potentilla recta*.

B. 'michiganense' has been found in the Grand Sable and Sleeping Bear dunes in Michigan where plants then thought to be *B. hesperium* are now known to be *B. 'michiganense'* (Anderson and Cariveau 2004). Habitats documented in Minnesota for *B. 'michiganense'* include tailings ponds, gravel pits, ditches, an old log landing, and along a weedy roadside (Chadde and Kudray 2001) and herbaceous openings such as old homesteads and moist to dry brush fields (Wilfahrt 2001). In the Lake Superior area *B. 'michiganense'* often grows *with B. acuminatum* and *B. matricariifolium* (Wagner and Wagner 1986). In Wyoming, *B. 'michiganense'* is found in a *Pinus ponderosa* forest with *Populus tremuloides*.

Wagner and Wagner (1993) indicate an elevation range of 656 to 9,186 feet, but *B. 'michiganense'* on the Idaho Panhandle National Forests occurs at the lower elevations. Colorado element occurrence records document populations between 9,849 and 11,269 feet in elevation (Anderson and Cariveau 2004). In Wyoming, *B. 'michiganense'* is found at 5,000 feet (Anderson and Cariveau 2004). In South Dakota, *B. 'michiganense'* is found between 4,921 and 5,380 feet (Anderson and Cariveau, 2004).

2.5.5 Population Biology and Viability

There was only one plant found at the Idaho Panhandle National Forests site. This plant was originally observed on June 22, 2000 and plant vigor was assessed as good. The site was revisited in July 19, 2000 and the plant was documented as "withered". No new plants were observed.

2.5.6 Summary of Land Ownership and Existing Habitat Protection

The single documented population of *B. michiganense* in Idaho is documented on the Idaho Panhandle National Forests in the Sandpoint Ranger District in land allocated for timber production (MA4).

2.5.7 Current or Potential Threats to Habitat and Management Activities

Field notes describe that the documented Idaho Panhandle National Forests plant may become shaded out by the upper canopy of 20-year old conifers. There is no evidence of grazing. However, evidence of occasional vehicle traffic is documented in areas where the saplings are sparse. The small amount of occupied habitat and extremely low number of individuals, combined with ongoing threats, make this population vulnerable to extirpation.

Because of the low occurrence numbers, conservation management for *Botrychium 'michiganense'* should be a high priority for the sensitive plant program on the Idaho Panhandle National Forests. The single site should be relocated and detailed habitat information recorded. The site is located on land allocated for timber harvest (MA4), and the Idaho Panhandle National Forests should consider proposals of management activities at the confluence of Gold and West Gold Creeks (refer to Section 1.5).

2.5.8 Past and Current Conservation Activities

Given the probability that more populations may be discovered on the Idaho Panhandle National Forests, further survey work is an important research need for *Botrychium 'michiganense'.* Further targeted inventory work would allow land managers to assess the rarity and conservation priority of this species. Until the species is formally described, it will not be possible to formulate conservation strategies that address the specific needs of the species (refer to Section 1.6).

2.5.9 Research and Monitoring

Refer to Section 1.7.

2.6 Mingan Moonwort (*Botrychium minganense*)

2.6.1 Classification and Status

Classification: Refer to Section 1.1 (Nomenclature and Taxonomy).
Status: Refer to Appendix A.

2.6.2 Description

Refer to Appendices B and C.

2.6.3 Distribution and Abundance

Mingan moonwort is rare but is one of the most widespread North American species, occurring in practically all parts of Canada and Alaska, and ranging widely in the mountains of the western United States, south to Arizona (Wagner and Devine, 1989).

A total of 60 sites of Mingan moonwort are currently documented in Idaho and 43 of these sites are within the Idaho Panhandle National Forests boundaries. The West Fork Fish Hook Creek site has not been recorded by the ICDC, but the USFS is currently submitting the data to ICDC (DiGiacomo 2004 pers. comm.). Several of the sites (EO #6, 8, 9, 19, 22, 25, 31, 41, 48, 49, and 52) are represented by more than one point on the EO data map. Refer to Appendix E for the EO data table and Appendix F for the map displaying occurrences on the Idaho Panhandle National Forests.

Rex Daubenmire first collected *Botrychium minganense* on the Priest River Experimental Forest in Idaho under the name of *B. lunaria* in 1963. During a field survey on the Idaho Panhandle National Forests in 1987, Norm Trigoboff located a population (EO #2) that was identified as *B. lunaria* (Caicco 1987). This specimen was later annotated to *B. minganense* by R.K. Moseley in 1989 (Lorain 1990). Chris Lorain discovered another population (EO #3) during a survey by the Idaho Natural Heritage Program conducted in 1989 on the Clearwater National Forest in Clearwater County (Lorain 1989). Site EO #3 along with 17 other sites is located outside the boundaries of the Idaho Panhandle National Forests. There is no EO #1 in the ICDC database.

During the 1990 inventory survey, three new sites tentatively identified as *B. minganense* were discovered on the Idaho Panhandle National Forests (Lorain 1990). One site (EO #4) was found on an alluvial terrace of the Moyie River about two miles north of Moyie Springs in Boundary County. The second site (EO #5) was discovered in the Coeur d'Alene River drainage in Shoshone County. A third new population (EO #6) was discovered in Boundary County south of Brush Lake along the edge of a small pond (Lorain 1990). Since the 1990 inventory survey, 37 new sites of *B. minganense* have been documented on the Idaho Panhandle National Forests. Refer to Appendix E for the EO data table and Appendix F for the maps displaying occurrences on the Idaho Panhandle National Forests.

2.6.4 Habitat

Mingan moonwort grows in a wide variety of habitats including meadows, prairies, woods, sand dunes, and riverbanks. Soils tend to be acid to circumneutral (pH near seven) in nature (Lellinger 1985). Throughout its range, *Botrychium minganense* grows in a broad variety of moist habitats. In Michigan, it usually grows in second growth deciduous forests (Wagner and Lord 1956). In Washington, it is found mostly in riparian areas with western redcedar or mixed conifers but is also reported from rocky subalpine and alpine habitats (Vanderhorst 1997). In Montana, it is known from rocky alpine areas, montane grasslands, mossy lakeshores, alder thickets, and conifer and deciduous forests. In Idaho, it is reported from western redcedar, hemlock, grand fir, and lodgepole pine forest habitat types as well as from alder thickets (Lorain 1990) in elevations ranging from 2,000 to 5,180 feet.

On the Idaho Panhandle National Forests in Idaho, plants have been documented from the following habitats: the understory of old-growth western redcedar forest, a dense brushfield, disturbed lodgepole pine community, a seasonal pond, floodplains of small streams, seasonally wet drainage bottoms, benches above creeks, riparian areas, an open meadow surrounded by cottonwoods, a broad swale, seep areas, and draw bottoms.

Elevations on the Idaho Panhandle National Forests are documented from 2,500 to 5,180 feet. The documented sites are usually shaded on moderate slopes from 0 to 40 percent on all aspects. Cover is generally from 60 to 90 percent. Many of the larger sites are found growing in old growth or mature western redcedar and western hemlock forests. Soils conditions at some of the sites are described as mineral-grantic, thick duff layer, duff litter over sand, organic soil over quartzite gravel and bedrock, volcanic ash soil, and rich duff.

Habitat types commonly associated with Mingan moonwort include the following: *Abies grandis/Clintonia uniflora* (grand fir/queen's cup beadlily) habitat type, *Abies lasiocarpa/ Xenophyllum tenax* habitat type, *Abies lasiocarpa/Clintonia uniflora* habitat type, *Pinus contorta/Vaccinium globulare* habitat type, *Thuja plicata/ Asarum caudatum* habitat type, *Thuja plicata/Adiantum pedatum* (western redcedar/maidenhair fern) habitat type, *Thuja plicata/Athyrium filix-femina* habitat type, *Thuja plicata/Clintonia uniflora* habitat type, *Thuja plicata/Oplopanax horridum* habitat type, *Tsuga heterophylla/Asarum caudatum/Aralia nudicaulis* (western hemlock/wild ginger/wild sarsaparilla) habitat type, *Tsuga heterophylla/Clintonia uniflora* habitat type, *Tsuga heterophylla/Gymnocarpium dryopteris* habitat type, and *Tsuga heterophylla/Thuja plicata* (western hemlock/ western redcedar) habitat type.

Species commonly found growing with Mingan moonwort on the Idaho Panhandle National Forests include tree, shrub, and forb species. Tree species include *Abies grandis*, *Abies lasiocarpa, Picea, engelmannii, Pinus contorta, Pinus monticola, Larix occidentalis, Philadelphus lewsii* (mock-orange), *Betula papyrifera, Populus tremuloides, Pseudotsuga menziesii, Taxus brevifolia, Thuja plicata,* and *Tsuga heterophylla.*

Shrub species include *Acer glabrum, Alnus incana, Alnus rubra* (red alder), *Alnus sinuata, Amelanchier alnifolia, Ceanothus sanguineus* (redstem ceanothus*), Cornus sericea, Menziesia ferruginea, Pachistima myrsinites, Ribes lacustre, Rosa gymnocarpa, Rubus leucodermis, Rubus parviflorus, Rubus pedatus, Rubus spectablis,* (salmonberry), *Rubus ursinus* (California blackberry), *Salix nivalis* (rocky mountain willow), *Salix scouleriana, Sambucus cerulea* (blue elderberry), *Sorbus scopulina* (western mountain ash), *Symphoricarpos albus, Vaccinium globulare,* and *Vaccinium membranaceum* (thinleaf blueberry).

Forbs, ferns, fern allies, sedges, and grasses species included the following:

- *Aconitum columbianum*
- *Actaea rubra*
- *Adenocaulon bicolor*
- *Anaphalis margaritacea*
- *Anemone piperi* (Piper's anemone),
- *Angelica arguta*
- *Aquilegia formosa* (scarlet columbine),
- *Aralia nudicaule* (barestem biscuitroot)
- *Aralia nudicaulis*
- *Arnica latifolia* (broadleaf arnica)
- *Arnica cordifolia* (heartleaf arnica),
- *Asarum caudatum*
- *Athyrium filix-femina*
- *B. crenulatum*
- *B. lanceolatum*
- *B. lunaria*
- *B. matricariifolium* (daisy leaf grapefern)
- *B. multifidum*
- *B. pinnatum*
- *B. virginianum*
- *B. echo* (desolation meadow grapefern)
- *Boykinia major*
- *Bromus vulgaris*
- *Calamagrostis canadensis*
- *Calamagrostis rubescens*
- *Cardamine oligosperma* (little western bittercress)
- *Carex deweyana*
- *Carex geyeri*

- *Cinna latifolia*
- *Circaea alpina*
- *Claytonia lanceolata* (lanceleaf springbeauty)
- *Clintonia uniflora*
- *Coptis occidentalis*
- *Cornus canadensis*
- *Corydalis caseana* (Case's corydalis)
- *Corylus cornuta* (beaked hazelnut)
- *Dicentra uniflora*
- *Disporum hookeri*
- *Dryas octopetala* (mountain avens)
- *Dryopteris austriaca*
- *Dryopteris carthusiana* (spinulose woodfern)
- *Dryopteris filix-mas*
- *Elymus glaucus*
- *Epilobium angustifolium*
- *Equisetum arvense* (field horsetail)
- *Erigeron humilis* (arctic alpine fleabane)
- *Festuca ovina* (sheep's fescue)
- *Festuca subulata*
- *Galium bifolium* (twinleaf bedstraw)
- *Galium trifidum*
- *Galium triflorum*
- *Geum macrophyllum*
- *Glyceria elata* (tall mannagrass)
- *Goodyera oblongifolia*
- *Gymnocarpium dryopteris*
- *Heracleum maximum*
- *Hieracium albiflorum* (white hawkweed)
- *Hieracium caespitosum* (yellow hawkweed)
- *Ligusticum canbyi*
- *Linnaea borealis*
- *Listera caurina* (northwestern twayblade)
- *Listera convallariodes* (broad lipped twayblade)
- *Listera cordata*
- *Lloydia serotina* (common alplily)
- *Lonicera involucrata*
- *Lonicera utahensis* (Utah honeysuckle)
- *Luzula divaricata* (forked woodrush)
- *Maianthemum stellatum* (starry false lily of the valley)
- *Melica subulata* (Alaska oniongrass)
- *Mentha arvense* (field mint)
- *Menziesia ferruginea*
- *Mertensia paniculata*
- *Mimulus guttatus* (seep monkeyflower)
- *Mitella caulescens* (tall bluebells)
- *Moneses uniflora*
- *Montia cordifolia*
- *Montia sibirica* (Sibrian miner's lettuce)
- *Nemophila breviflora* (baby blue eyes)
- *Oplopanax horridum*
- *Orthilla secunda* (one-sided wintergreen),
- *Osmorhiza berteroi*
- *Plantanthera dilatata* (tall white bog-orchid)
- *Poa alpina* (alpine bluegrass)
- *Polystichum andersonii* (Anderson's holly fern)
- *Polystichum lonchitis* (northern hollyfern)
- *Polystichum munitum*
- *Potentilla diversifolia* (varileaf cinquefoil)
- *Prunella vulgaris* (common selfheal)
- *Pteridium aguilinum*
- *Ranunculus uncinatus*
- *Rudbeckia occidentalis* (western coneflower)
- *Senecio triangularis*
- *Shepherdia canadensis* (russet buffaloberry)
- *Solidago multiradiata* (mountain goldenrod)
- *Stellaria crispa* (curled starwort)
- *Streptopus amplexifolius* (claspleaf twistedstalk)
- *Streptopus streptopoides*
- *Thalictrum occidentale*
- *Thelypteris phegopteris* (northern beech fern)
- *Tiarella trifoliata* (foamflower)
- *Trautvetteria carloinensis*
- *Trifolium haydenii* (Hayden's clover)
- *Trillium ovatum*
- *Veratrum viride*
- *Veronica americana* (American brooklime)
- *Viola glabella*
- *Viola orbiculata*
- *Waldsteinia idahoensis* (Idaho false strawberry)
- *Xerophyllum tenax* (Beargrass)

2.6.5 Population Biology and Viability

There are 42 documented sites and one undocumented site of *Botrychium minganense* on the Idaho Panhandle National Forests. Documented population numbers on the Idaho Panhandle National Forests are usually small, 23 sites (55 percent) consist of only one to 10 plants. However, nine sites (21 percent) have 50 to 1,000 or more individuals. These populations include Deer Park East (EO #6), Three Lakes Creek (EO #8), Giles Road at Upper Rock Creek (EO #19), Sand House Cedar Grove (EO #22), Spruce Mountain (EO #27), Packer Creek (EO #30), Leonia Knob (EO #41), and Two Tail Peak (EO #42). The majority of the large populations occur in mature stands of western redcedar and are associated with seeps or riparian areas.

On the Idaho Panhandle National Forests, *Botrychium minganense* is normally found in western redcedar and western hemlock habitat and 27 percent (11 sites) are located in mature to old growth habitat. However, there are three sites found in relatively disturbed habitat. This habitat is described as the following: disturbed upland *Pinus contorta* community (EO #4), a 30 year-old burned area (EO #5); upland meadow opening with canopy of sapling and pole sized trees (EO #17), near saplings in a clearcut unit (EO #33), at the end of a skid trail (EO #39), and in a fire-generated immature forest stand (EO #52).

Three of the sites (EO #25, 36, and 60) are documented adjacent to trails and one site was recorded in close proximity to a USFS road (EO #51). Four sites (EO #16, 19, 20, 32) were recorded with moss habitat associations.

Botrychium minganense populations on the Idaho Panhandle National Forests were found growing with other moonwort species including *B. lanceolatum, B. virginianum, B. crenulatum, B. multifidum, B. pinnatum,* and *B. montanum. B. virginianum* was the most common companion moonwort species.

2.6.6 Summary of Land Ownership and Existing Habitat Protection

Of the 59 total documented occurrences in North Idaho, 17 are located on land outside the Idaho Panhandle National Forests and 42 are located on the Idaho Panhandle National Forests. Several of the sites (EO#6, 8, 9, 19, 22, 25, 31, 41, 48, 49, and 52) are represented by more than one point on the EO data map. Refer to Appendix E for the EO data table and Appendix F for the map displaying occurrences on the Idaho Panhandle National Forests.

Three sites are located on the St. Joe Ranger District of the Idaho Panhandle National Forests, three are located on the Coeur d'Alene River Ranger District, six are located on the Sandpoint Ranger District, 13 are located on the Bonners Ferry Ranger District, and 17 are located on the Priest Lake Ranger District.

2.6.7 Current or Potential Threats to Habitat and Management Activities

Most (93 percent) of the occurrences of *B. minganense* on the Idaho Panhandle National Forests are on lands allocated for timber production in MAs 1, 2, 3, 4, 6, and 7. Two of the sites (EO #47 and EO #54) are located on lands designated as "Special Areas" (MA13) on the Priest Lake Ranger District and one of the sites (EO #10) is located on lands designated as "minimum management" (MA9). These areas are not allocated for timber production.

The Three Lakes Creek population (EO #8) has been affected by unauthorized ATV use (DiGiacomo 2004 pers. comm.). Other habitat-altering activities such as road building, timber harvesting, and drainage of swampy habitats pose threats to Mingan moonwort on the Idaho Panhandle National Forests. Refer to Section 1.5.

2.6.8 Past and Current Conservation Activities
Refer to Section 1.6.

2.6.9 Research and Monitoring
Refer to Section 1.7.

2.7 Western Goblin (Botrychium montanum)

2.7.1 Classification and Status

Classification: Refer to Section 1.1 (Nomenclature and Taxonomy).
Status: Refer to Appendix A.

2.7.2 Description
Refer to Appendices B and C.

2.7.3 Distribution and Abundance
This species occurs in British Columbia and Western North America from California, Oregon, Washington, northern Idaho, and northwestern Montana (ICDC 2004b). In Idaho, this species occurs in primarily Bonner and Boundary counties, but also in Shoshone and Latah counties (ICDC 2004b).

Currently, there are 17 sites in Idaho; 16 are ICDC documented sites and one site is documented with the USFS, St. Joe Ranger District of the Idaho Panhandle National Forests but is not recorded in the ICDC database (DiGiacomo 2004 pers. comm.). Fourteen of these sites are located on the Idaho Panhandle National Forests (ICDC 2004a). Three sites are located outside the Idaho Panhandle National Forests (EO#3, 4, and 9). Several of the sites (EO#5, 6, 8, and 10) are represented by more than one point on the EO data map. Refer to Appendix E for the EO data table and Appendix F for the maps displaying occurrences on the Idaho Panhandle National Forests.

2.7.4 Habitat
Botrychium montanum mostly occur in mature to old growth western redcedar and western hemlock stands having a depauperate understory and deep litter layer. It is often associated with small hydrological features such as seeps, rivulets, draws, and swales and the microtopography is usually level or patterned. It is known from elevations up to about 6,500 feet (ICDC 2004b). Nearly all Montana, Idaho and Washington occurrences are in *Thuja plicata* (western redcedar) or *Tsuga heterophylla* (western hemlock) habitat types (Vanderhorst 1997). In Oregon, the species has been found in 10 year-old clearcuts with regeneration on the Umatilla National Forest and in partially shaded mesic meadows in the Wallowa Mountains (Zika and Alverson 1996).

Most of the sites on the Idaho Panhandle National Forests are located in draw bottoms or riparian areas in moist soil or duff layer at elevations from 2,500 to 4,300 feet. The canopy cover is generally 80 to 90 percent. The sites on the Idaho Panhandle National Forests generally occurred on slopes of less than 30 percent on all aspects.

Habitat types commonly associated with western goblin on the Idaho Panhandle National Forests include the following: *Thuja plicata/ Asarum caudatum* habitat type, *Thuja plicata/Athyrium filix-femina* habitat type, *Thuja plicata/Oplopanax horridum* habitat type, *Tsuga heterophylla/Asarum caudatum/Aralia nudicaulis* (western hemlock/wild ginger/wild sarsaparilla) habitat type, *Tsuga heterophylla/Clintonia uniflora* habitat type, and *Tsuga heterophylla/Gymnocarpium dryopteris* habitat type.

Species commonly found growing with western goblin on the Idaho Panhandle National Forests include tree, shrub, and forb species. Tree species include *Abies grandis, Abies lasiocarpa, Betula papyrifera, Picea engelmannii, Pinus monticola, Populus tremuloides, Pseudotsuga menziesii, Populus triocharpa, Symphoricarpos albus, Taxus brevifolia, Thuja plicata,* and *Tsuga heterophylla.*

Shrub species commonly found growing with western goblin on the Idaho Panhandle National Forests include *Alnus incana, Rosa gymnocara, Symphoricarpos albus,* and *Vaccinium membranaceum* (thinleaf blueberry), and *Vaccinium ovalifolium* (oval-leaf blueberry).

Forbs, ferns, fern allies, sedges, and grasses species commonly found growing with western goblin on the Idaho Panhandle National Forests include the following: :*Actaea rubra, Adenocaulon bicolor, Aralia nudicaulis, Asarum caudatum, Athyrium filix-femina, B. multifidum, B. pinnatum, B. virginianum, Cinna latifolia, Circaea alpina, Clintonia uniflora, Coptis occidentalis, Cornus canadensis, Disporum hookeri, Galium trifidum, Galium triflorum, Geum macrophyllum, Glyceria elata* (tall mannagrass), *Goodyera oblongifolia, Gymnocarpium dryopterisHabenaria saccata*, *Hieracium albiflorum* (white hawkweed), *Linnaea borealis, Maianthemum stellata, Menziesia ferruginea, Oplopanax horridum, Orthilla secunda* (one-sided wintergreen), *Osmorhiza berteroi, Pteridium aquilinum, Plantanthera stricta* (slender bog-orchid), *Rudbeckia occidentalis* (western coneflower), *Streptopus amplexifolius, Streptopus streptopoides, Tiarella trifoliata, Trillium ovatum,* and *Viola glabella*.

2.7.5 Population Biology and Viability

There are 15 sites located on the Idaho Panhandle National Forests. Seven sites (47 percent) of the documented sites on the Idaho Panhandle National Forests have less than 20 plants. However, two sites (EO #6 and 8) have more than 100 plants. The largest population (EO #6) contains a total of 168 plants scattered on the slopes of Jeru Ridge, north of Jeru and Lindsey Creeks in Boundary County. The EO habitat description for the large population states that the species occurs on wet, seepy areas on draw bottoms and wet benches. The habitat types in this area included *Thuja plicata/Asarum caudatum, Thuja plicata/Athyrium filix-femina, Thuja plicata/Oplopanax horridum,* and *Tsuga heterophylla/Gymnocarpium dryopteris.* Associated plant species include *Abies grandis, Abies lasiocarpa, Picea engelmannii, Populus tremuloides, Taxus brevifolia, Alnus incana, Clintonia uniflora, Maianthemum stellata, Viola glabella, Pteridium aguilinum,* and *Cinna latifolia.*

The second largest population (EO #8) includes a total of 132 estimated plants observed in 1998 scattered along the headwaters of Cocolalla Creek in Bonner County. This population was found in a riparian draw bottom and bench in moist forest habitat and deep duff. The habitat types in this area included *Thuja plicata/ Asarum caudatum* and *Abies lasiocarpa/Clintonia uniflora*. Other associated plant species include *Abies grandis, Populus trichocarpa, Betula papyrifera, Pseudotsuga menziesii, Trillium ovatum, Goodyera oblongifoilia, Pyrola* sp. (wintergreen sp.), and *Gymnocarpium dryopteris.*

Other *Botrychium* species found growing with *Botrychium montanum* included *Botrychium virginianum*, *Botrychium minganense, Botrychium multifidum*, and *Botrychium pinnatum.* Only one documented site (EO #16) describes the surrounding tree size and habitat as old growth and consequently only one plant was found in this location. *Thuja plicata* was present in all the site location habitats.

2.7.6 Summary of Land Ownership and Existing Habitat Protection

Fifteen sites of *Botrychium montanum* occur on the Idaho Panhandle National Forests. Several of the sites (EO#5, 6, 8, and 10) are represented by more than one point on the EO data map. Refer to Appendix E for the EO data table and Appendix F for the maps displaying occurrences on the Idaho Panhandle National Forests.

Three sites are located on the Sandpoint Ranger District, one is found on the Bonners Ferry Ranger District, three are found on the St. Joe Ranger District - one of which is not documented in the ICDC database but is on file with the Idaho Panhandle National Forests (DiGiacomo 2004 pers. comm.), and seven are on the Priest Lake Ranger District. Two of the sites (EO#2 and the Three Lakes Creek site) are protected in cedar stands allocated as old growth, removed from timber production. The remaining sites are located in land allocated for timber production (MA1, 2, 3, 4, 6, and 7).

2.7.7 Current or Potential Threats to Habitat and Management Activities

On the Idaho Panhandle National Forests, most of the populations are associated with wet draws and riparian areas. Most of the sites (86 percent) are located on Idaho Panhandle National Forests land allocated for timber production (MA1, 2, 3, 4, 6, and 7). Two sites (EO#2 and the Three Lakes Creek site) on the Idaho Panhandle National Forests are protected in cedar stands allocated as old growth, removed from timber production. However, the Three Lakes site has been affected by unauthorized ATV use (DiGiacomo 2004 pers. comm.). Habitat-altering activities such as road building, timber harvesting, and drainage of wet areas pose threats to western goblin on the Idaho Panhandle National Forests. It appears that the species requires fairly dense shade [80 to 90 percent cover (ICDC 2004a)] so activities that would alter the overstory could also threaten the species. Three of the populations are located adjacent to a pack trail (E0#13), a hunter's trail (EO#15) and a hiking trail (EO#16). These sites may be threatened by impacts associated with recreational activities such as hiking, trampling or campfires (refer to Section 1.5).

2.7.8 Past and Current Conservation Activities

Two sites (EO #2 and the Three Lakes Creek site) on the Idaho Panhandle National Forests are protected in cedar stands allocated as old growth, removed from timber production. The Jeru Ridge population was discovered during rare plant surveys for a timber harvest project. The occurrences were buffered from all timber harvest activities (Hammet 2004, pers. comm.).

2.7.9 Research and Monitoring

Refer to Section 1.7.

2.8 Paradox Moonwort (*Botrychium paradoxum*)

2.8.1 Classification and Status

Classification: Refer to Section 1.1 (Nomenclature and Taxonomy).
Status: Refer to Appendix A.

2.8.2 Description

Refer to Appendices B and C.

2.8.3 Distribution and Abundance

This species occurs from Alberta, British Columbia, Saskatchewan, Montana, Utah, Oregon, and Washington (Vanderhorst 1997). In Idaho, there is one documented occurrence of *Botrychium paradoxum* in Boundary County (ICDC 2004a) on the Idaho Panhandle National Forests. Refer to Appendix E for the EO data table and Appendix F for the maps displaying occurrences on the Idaho Panhandle National Forests.

2.8.4 Habitat

The habitats of *Botrychium paradoxum* throughout its range are diverse, but most sites are montane to subalpine grasslands or forb dominated meadows (ICDC, 2004b). In Montana, *Botrychium paradoxum* grows on glaciated slopes and ridgetops, and in glaciated lake basins, stream bottoms and draws. In Utah, the species was collected from subalpine "meadows" (Vanderhorst, 1997) and in Oregon all occurrences are in mesic meadows (Zika, 1994). In Washington it grows in meadows and forests (Vanderhorst, 1997). Wagner and Wagner (1993) state that *B. paradoxum* usually grows "in snowfields and secondary growth pastures." Throughout its range, *B. paradoxum* has been reported growing with *B. hesperium, B. lanceolatum, B. lunaria, B. minganense, B. pinnatum, B. pedunculosum* and *B. simplex* (Vanderhorst 1993, Wagner and Wagner 1983, Zika, 1992).

The single population on the Idaho Panhandle National Forests (EO #1) was discovered in a draw bottom growing on moss-covered rocks beside an old skid road at an elevation of 3,200 feet. The site is at the south end of Perkins Lake in Boundary County on the Bonners Ferry Ranger District. The site was found in *Tsuga heterophylla/Gynocarpium dryopteris* habitat type. Associated plant species included *Tsuga heterophylla, Betula paprifera, Thuja plicata, Acer glabrum, Gymnocarpim dryopteris,* moss spp., *Viola glabella,* and *Osmorhiza berteroi*. No other *Botrychium* species were observed growing with *Botrychium paradoxum* at this site.

2.8.5 Population Biology and Viability

The single documented occurrence (EO #1) of *Botrychium paradoxum* on the Idaho Panhandle National Forests was on a 14 percent slope and western aspect. The canopy closure was 95 percent suggesting that shading is an important component of the habitat. Moss-covered rocks were observed.

Lesica and Ahlenslager (1996) conducted demographic studies of a population that included *Botrychium paradoxum, B. hesperium,* and their putative hybrid *B. X watertonense* in Waterton Lakes Park, Alberta. Of the three taxa, *B. paradoxum* had the highest rates of mortality and recruitment, and they suggest that it is the most adapted to ephemeral habitats and is the most prone to cycles of extinction and recolonization.

Demographic data from Lesica and Ahlenslager (1996) suggest that *B. paradoxum* may be favored by some disturbance due to the sporophytes short life and poor competitive ability.

All *Botrychium* species are believed to be obligately dependent on mycorrhizal relationships in both the gametophyte and sporophyte generations. Zika (1992) reported an abundance of *Fragaria virginiana* (strawberry) in *B. paradoxum* habitat in Oregon and J. Vanderhorst observed the same association in the Anaconda Range (Vanderhorst 1993). These relationships may be a manifestation of mycorrhizal links between

these plants. *Fragaria virginiana* was not found associated with *B. paradoxum* on the Idaho Panhandle National Forests.

2.8.6 Summary of Land Ownership and Existing Habitat Protection

The single population of *Botrychium paradoxum* is located on Bonners Ferry District of the Idaho Panhandle National Forests.

2.8.7 Current or Potential Threats to Habitat and Management Activities

The site was found beside an old skid road in a draw bottom and is in MA2, which is allocated for timber production on the Idaho Panhandle National Forests. The population was discovered during rare plant surveys for a timber sale; it was buffered from all harvest activities (Hammet 2004 pers. comm.). The extremely low number of *Botrychium paradoxum* on the Idaho Panhandle National Forests raises concern about population viability for this species.

2.8.8 Past and Current Conservation Activities

Refer to Section 1.6.

2.8.9 Research and Monitoring

Surveys to relocate the single location of *Botrychium paradoxum* have not been conducted since its discovery in 1995. Therefore, it is recommended that EO #1 be relocated and a detailed habitat description be documented (refer to Section 1.7).

2.9 Stalked Moonwort (Botrychium pedunculosum)

2.9.1 Classification and Status

Classification: Refer to Section 1.1 (Nomenclature and Taxonomy).
Status: Refer to Appendix A.

2.9.2 Description

Refer to Appendices B and C.

2.9.3 Distribution and Abundance

This species has been documented in Western North America: Alberta, Saskatchewan, Oregon, Washington, northern Idaho, and northwestern Montana (ICDC 2004b). There are currently three occurrences of *Botrychium pedunculosum* in Idaho and all are located on the Idaho Panhandle National Forests. EO#3 is actually the *B. 'michiganense'* EO, but was originally turned in to the ICDC as *B. pedunculosum*. Two sites are located near Priest Lake in Bonner County (EO #2 and EO #4) and the third site (EO #1) is located at the confluence of Shoshone Creek and Pine Flats Creek in Shoshone County. Refer to Appendix E for the EO data table and Appendix F for the maps displaying occurrences on the Idaho Panhandle National Forests.

2.9.4 Habitat

In general, this species is commonly found in open habitats such as mesic to moist meadows, swales, and along roadsides. In the Wallowa Mountains of Oregon where *B. pedunculosum* is most abundant, it grows in abandoned oxbows with heavy cover by grasses and in openings in *Pinus contorta* forests in close association

with *Fragaria virginiana* (Zika 1994). In Washington it grows in moist meadows, swales, and roadsides (Vanderhorst 1997). In Montana, it is most abundant in old growth stands of *Thuja plicata* in floodplain bottoms (Vanderhorst 1997). In Idaho, it has been found in a disturbed meadow and with western hemlock or western redcedar in riparian draws and alluvial bottoms at elevations ranging from 2,440 to 2,990 feet.

The sites on the Idaho Panhandle National Forests are associated with *Tsuga heterophylla/Gymnocarpium dryopteris* habitat, *Thuja plicata* habitat, and *Thuja plicata/Athyrium filix-femina* habitat. Associated tree species include *Abies grandis, Picea engelmannii, Abies lasiocarpa, Tsuga heterophylla, Pinus monticola,* and *Pseudotsuga menziesii.* Associated shrub species include *Symphoricarpos albus, Rhamnus purshiana, Rubus parviflorus, Acer glabrum,* and *Amalanchier alnifolia.* Associated forbs, ferns, fern allies, sedges, and grasses include *Botrychium lanceolatum, Osmorhiza purpurea, Mertensia paniculata, Rudbeckia occidentalis, Senecia integerrimus, Fragaria vesca, Cerastium* sp., *Achillea millefolium, Antennaria* sp., *Galium triflorum, Prunella vulgaris, Heracleum maximum, Viola glabella, Asarum caudatum, Arnica* sp., *Solidago canbyi, Veronica serpyllifolia, Aconitum columbianum, Agrostis tenuis, Agrostis thurberiana, Poa scabrella, Phleum pratense, Elymus glaucus, Carex crawfordii, Carex breweri* (Brewer's sedge), and *Bromus vulgaris.*

The sites on the Idaho Panhandle National Forests were found at elevations ranging from 2,500 to 2,990 feet. The Shoshone Creek siting (EO #1) was found on a northern aspect with 10 percent canopy closure. EO #4 did not indicate aspect. The habitat of this species on the Idaho Panhandle National Forests varies from wet riparian areas to dry upland pine forest. Two of the sites, EO #1 (Shoshone Creek) and EO #4 (Ruby Creek) were assocated with riparian areas.

2.9.5 Population Biology and Viability

The sites in Idaho on the Idaho Panhandle National Forests were relatively small, consisting of one to 30 plants. The site (EO #4) with 30 plants was found scattered on both sides of Ruby Creek. The area was described as moist with low light. A long fire interval was also noted. Site EO #1 had only ten percent canopy closure and five plants.

Fronds of *B. pendunculosum* appear as early as late spring and die in early fall (Wagner and Wagner 1993). Phenology is greatly affected by moisture of the microsite; wetter habitats delay maturation and senescence (Zika, 1994).

2.9.6 Summary of Land Ownership and Existing Habitat Protection

EO #2 and EO #4 are located on the Priest Lake Ranger District and EO #1 is located on the Coeur d'Alene River Ranger District. The management area of EO #2 is unknown, and the remainder of the sites are allocated for timber production on MAs 1, 3 and 4.

2.9.7 Current or Potential Threats to Habitat and Management Activities

Refer to Section 1.5.

2.9.8 Past and Current Conservation Activities

Refer to Section 1.6.

2.9.9 Research and Monitoring

Refer to Section 1.7.

2.10 Northwestern Moonwort (*Botrychium pinnatum*)

2.10.1 Classification and Status

Classification: Refer to Section 1.1 (Nomenclature and Taxonomy).
Status: Refer to Appendix A.

2.10.2 Description

Refer to Appendices B and C.

2.10.3 Distribution and Abundance

Northwestern moonwort is rare and local but exhibits a rather extensive range. It is known to occur in Alaska and the Yukon Territory, southward at higher elevations in the mountains of Pacific Northwest states, northern California, Nevada, Utah, Colorado, and Wyoming (ICDC, 2004b).

Twenty sites of Northwestern moonwort are now documented in Idaho and 17 of these are located on the Idaho Panhandle National Forests. One of the sites (EO#8) is represented by more than one point on the EO data map. Refer to Appendix E for the EO data table and Appendix F for the maps displaying occurrences on the Idaho Panhandle National Forests.

Two of the sites on the *Botrychium pinnatum* were first recorded (EO #1) in 1989 by Robert Moseley during a survey by the Idaho Natural Heritage Program on the Idaho Panhandle National Forests (Lorain 1990). During the 1990 survey, the Moseley collection from Boundary County was relocated and a more thorough investigation revealed that the EO #1 population consists of some 50 plants versus the single plant originally found (Lorain 1990). In addition, three new sites were discovered in 1990 on the Idaho Panhandle National Forests (EO #2, EO #3, and EO #4). Since 1990, 13 new sites of *Botrychium pinnatum* have been discovered on the Idaho Panhandle National Forests.

2.10.4 Habitat

Northwestern moonwort grows in a wide variety of habitats including wet to moist grassy slopes, streambanks, roadsides, and in mossy woods, generally in the mountains (Wagner and Wagner 1983, Lellinger 1985). Idaho occurrences vary, from moist and mesic meadows to spruce bottoms and shaded western hemlock or western redcedar forests (ICDC, 2004b).

On the Idaho Panhandle National Forests, plants have been documented from a variety of habitats including open riparian meadow, shaded western redcedar forest floor, shrubby roadside, near a small spring within the *Abies lasiocarpa* zone, in a small, flat depression near the edge of a small pond, in a saturated *Poa pratensis* meadow, bottom of a small draw, sapling and pole-sized forest, open meadow, and cottonwood swamp. Elevations range from 2,700 to 5,180 feet. The slopes vary from 0 to 40 percent on all aspects and canopy closure varies from 50 to 100 percent.

Associated habitat types on the Idaho Panhandle National Forests include the following:

Abies grandis/Clintonia uniflora habitat type, *Abies lasiocarpa/Clintonia uniflora* habitat type, *Abies lasiocarpa/Vaccinium caespitosum* (subalpine fir/ dwarf bilberry) habitat type, *Thuja plicata/Asarum caudatum* habitat type, *Thuja plicata/Athyrium filix-femina* habitat type, *Thuja plicata/Clintonia uniflora* habitat type, *Thuja plicata/Oplopanax horridum* habitat type, *Tsuga heterophylla/Clintonia uniflora* habitat type, *Tsuga heterophylla/Clintonia uniflora/Aralia nudicaulis* (western hemlock/ queen's cup beadlily/wild sarsaparilla) habitat type, *Tsuga heterophylla/Gymnocarpium* habitat type, and *Tsuga heterophylla/Asarum caudatum* (western hemlock/wild ginger) habitat type.

Species commonly found growing with northwestern moonwort include trees, shrubs and forbs. Tree species include *Abies grandis, Abies lasiocarpa, Betula papyrifera, Larix occidentalis, Picea engelmanii, Pinus contorta, Pinus monticola, Prunis vulgaris, Pseudotsuga menziesii, Thuja plica,* and *Tsuga heteropylla.*

Shrub species commonly associated with *Botrychium pinnatum* on the Idaho Panhandle National Forests include *Acer glabrum, Alnus sinuata, Cornus sericea, Rosa gymnocarpa, Rubus parviflora, Salix* sp., *Sambucus racemosa, Sorbus sitchensis* (western mountain ash), *Spiraea douglasii* (Douglas spirea), *Symphoricarpos alba, Vaccinium scoparium,* and *Vaccinium membranaceum.*

Forbs, ferns, fern allies, sedges, and grasses species commonly associated with *Botrychium pinnatum* on the Idaho Panhandle National Forests include the following:

- *Achillea millefolium*
- *Aconitium columbianum*
- *Actaea rubra*
- *Agrostis stolonifera*
- *Anaphilis margaritacea*
- *Angelica arguta*
- *Aralia nudicaule*
- *Arnica cordifolia* (heartleaf arnica)
- *Arnica cordifolia*
- *Asarum caudatum*
- *Aster modestus*
- *Athyrium filix-femina*
- *Botrychium ascendens*
- *B. crenulatum*
- *B. lanceolatum*
- *B. lanceolatum*
- *B. minganense*
- *B. multifidum*
- *B. virginiana*
- *Bromus marginatus*
- *Bromus vulgaris*
- *Calamagrostis canadensis*
- *Calamagrostis rubescens*
- *Carex geyeri*
- *Carex hoodii*
- *Carex microptera*
- *Castilleja spp.*
- *Chimaphila umbellata*
- *Cirsium arvense*
- *Clintonia uniflora*
- *Dactylis glomerata*
- *Danthonia intermedia* (timber oatgrass)
- *Disporum hookeri*
- *Dryopteris filix-mas*
- *Elymus glaucous*
- *Epilobium* sp.
- *Equisetum arvense*
- *Festuca spp.*
- *Fragaria vesca*
- *Fragaria virginiana*
- *Galium trifidum*
- *Geum macrophyllum*
- *Gymnocarpium dryopteris*
- *Habenaria saccata*
- *Hieracium albiflorum*
- *Hieracium pratense*
- *Juncus ensifolius*
- *Ledum glandulosum*

- *Leucantheum vulgare*
- *Ligusticum canbyi*
- *Linnaea borealis*
- *Lonicera involucrata*
- *Lonicera utahensis*
- *Maianthemum racemosa*
- *Maianthemum stellata*
- *Mentha arvense*
- *Menziesii ferruginea*
- *Mertensia paniculata*
- *Orthilla secunda*
- *Osmorhiza berteroi*
- *Pachistima myrsinites*
- *Pedicularis bracteosa* (bracted lousewort)
- *Phalaris arundinacea* (reed canarygrass)
- *Phleum pratense*
- *Poa pratensis*
- *Poa spp.*
- *Polemonium occidentale*
- *Polystichum munitum*
- *Populus trichocarpa*
- *Potentilla* sp.
- *Prunella vulgaris*
- *Pyrola asarifolia*
- *Pyrola minor*
- *Senecio triangularis*
- *Solidago canadensis*
- *Streptopus amplexifoliu*
- *Tiarella trifoliata*
- *Trautvetteria carolinensis*
- *Trillium ovatum*
- *Valeriana sitchensis* (*Sitka Valarian*)
- *Viola glabella*
- *Viola orbiculata*
- *Xerophyllum tenax.*

2.10.5 Population Biology and Viability

Most (88 percent) of the occurrences contain fewer than 10 plants and 71 percent of the sites have only one to two plants present. Most populations of *Botrychium pinnatum* on the Idaho Panhandle National Forests are found in moist forest. Two of the occurrences (EO #7 and EO #16) were found in sapling or pole-sized forest and only one site is located in old growth habitat (EO #14). One occurrence was documented in thick moss (EO #4), indicating the mycorrhizal relationship of the species. The largest documented site (EO #6) consists of 125 plants and was found in a moist meadow adjacent to Big Elk Creek on the Coeur d'Alene River Ranger District. Other associated *Botrychium* species at this site included *Botrychium lanceolatum* and *Botrychium multifidum*. There were 60 *B. lanceolatum* plants and 125 *Botrychium pinnatum*, indicating that both species can thrive in the same habitat and competition among these species is low.

2.10.6 Summary of Land Ownership and Existing Habitat Protection

Seventeen of the 20 documented sites of northwestern moonwort in Idaho occur on the Idaho Panhandle National Forests. Five occur on the Priest Lake Ranger District, six occur on the Bonners Ferry Ranger District (one site is represented by more than one point on the EO Data map (Appendix E), one occurs on the Sandpoint Ranger District, and five occur on the Coeur d'Alene Ranger District. One of the sites (EO#8) is represented by more than one point on the EO data map. Refer to Appendix E for the EO data table and Appendix F for the maps displaying occurrences on the Idaho Panhandle National Forests.

EO #1 is located in MA9, a minimum management area and EO #3 is located in the Canyon Creek Research Natural Area (MA14). Both of these management areas are protected from logging activities. The remaining sites are allocated for timber production on MAs 1, 2, 3, 4, 6, 7, and 19 (refer to Section 1.5).

2.10.7 Current or Potential Threats to Habitat and Management Activities

Only one site (EO #14) was recorded in old growth habitat. EO #16 was found in a clear cut area surrounded by a sapling stand and EO #7 was found in sapling and pole-sized timber. There are currently only 17 documented populations of *B. pinnatum* on the Idaho Panhandle National Forests and many with only one plant documented. Therefore, these sites should be relocated and protected by the Idaho Panhandle National Forests.

2.10.8 Past and Current Conservation Activities

Refer to Section 1.6.

2.10.9 Research and Monitoring

Refer to Section 1.7.

2.11 Least Moonwort (*Botrychium simplex*)

2.11.1 Classification and Status

Classification: Refer to Section 1.1, *Nomenclature and Taxonomy*.
Status: Refer to Appendix A.

2.11.2 Description

Refer to Appendices B and C.

2.11.3 Distribution and Abundance

Least moonwort is regarded as rare and local but has an enormous range in North America and is probably much more common than usually assumed (Wagner and Devine 1989). It is known to occur from high elevations in southern California and North Carolina northward to Alaska and Newfoundland, and is also widespread in the Old World (Wagner and Devine, 1989).

Fourteen occurrences of least moonwort are now documented for Idaho in the northern and central portions of the state, including Bonner, Boundary, Clearwater, Latah, and Custer counties. Seven of these sites (EO #3, 4, 5, 6, 7, 12, and 15) occur on the Idaho Panhandle National Forests. However, EO#5 and EO#15 are incorrectly shown outside the boundaries of the IPNF in the ICDC mapping database (ICDC 2004a) and are not depicted on the maps in Appendix F. Efforts are underway to correctly map these two EO's. There is no EO #1 in the ICDC database. Refer to Appendix E for the EO data table and Appendix F for the maps displaying occurrences on the Idaho Panhandle National Forests.

2.11.4 Habitat

In general, least moonwort grows in moist to dry meadows, bogs, swamps, roadside ditches, dry fields, and forests at mid elevations in the mountains (ICDC, 2004b). The northern Idaho populations are found at elevations ranging from 2,620 to 3,020 feet. Habitat associated with least moonwort on the Idaho Panhandle National Forests ranges from upland shady forest near small creek, shore of a seasonal pond, dry pole-sized forest stand along a roadside, abandoned clearing of young trees, and along a roadside. Associated soils were described as sandy, granitic, and silty. On the Idaho Panhandle National Forests, *B. simplex* occurs on all aspects

at elevations ranging from 2,620 to 3,700 feet, at slopes from 0 to 15 percent and canopy closures from 10 to 35 percent. There are no other associated *Botrychium* species found at these sites.

The habitat types associated with *B. simplex* on the Idaho Panhandle National Forests include the following: *Thuja plicata/ Gymnocarpium dryopteris* habitat type, *Thuja plicata/Tsuga heterophylla* (western redcedar/western hemlock) habitat type, *Thuja plicata/Clintonia uniflora* habitat type, and *Thuja plicata/Athyrium felix-femina*.

Species commonly found growing with least moonwort on the Idaho Panhandle National Forests include trees, shrubs and forbs. Tree species consisted of *Abies grandis, Abies lasiocarpa, Crataegus douglasii, Larix occidentalis, Picea engelmani, Pinus contorta, Pinus ponderosa, Pseudotsuga menziesii, Thuja plicata, Taxus brevifolia,* and *Tsuga heterophylla.*

Shrub species commonly found growing with least moonwort on the Idaho Panhandle National Forests include *Alnus incana*, *Amelanchier alnifolia, Betula glandulosa* (scrub birch), *Fragaria vesca, Fragaria viginiana, Pachistima myrsinites, Physocarpus malvaceus* (mallow ninebark), *Salix myrtillifolia* (Booth's willow), *Salix scoulariana, Symphoricarpos albus, Vaccinium membranaceum,* and *Vaccinum ovalifolium* (Alaska early blueberry).

Forbs, ferns, fern allies, sedges, and grasses found associated with least moonwort on the Idaho Panhandle National Forests include the following:

- *Achillea millefolium*
- *Agrostis stolonifera*
- *Alnus incana*
- *Antennaria microphylla*
- *Antennaria rosea*
- *Antennaria umbrinella*
- *Aralia nudicaulis*
- *Asarum caudatum*
- *Athyrium felix-femina*
- *Berberis repens*
- *Bromus inermis*
- *Carex lenticularis*
- *Calochortus elegans* (elegant mariposa lily)
- *Calochortus nitidus* (broadfruit mariposa lily)
- *Caltha biflora*
- *Carex lenticularis*
- *Centaurea biebersteinii*
- *Chimaphila menziesii*
- *Circea alpina*
- *Clintonia uniflora*
- *Collinsia parviflora*
- *Coptis occidentalis*
- *Dactylis glomerata*
- *Danthonia californica*
- *Danthonia intermedia*
- *Deschampsia cespitosa* (tufted hairgrass)
- *Drypoteris expansa*
- *Equisetum arvense*
- *Erythronium grandiflorum* (glacier lily)
- *Festuca idahoensis* (Idaho fescue)
- *Galium triflorum*
- *Gentiana calycosa* (Rainier pleated gentian)
- *Galium aparine* (annual bedstraw)
- *Geum triflorum* (prairie smoke)
- *Goodyera oblongifolia*
- *Gymnocarpium dryopteris*
- *Hesperochiron pumilus* (few-flowered shooting star)
- *Hieracium pratense* (yellow hawkweed)
- *Hieracium caespitosum* (meadow hawkweed)
- *Holodiscus discolor*
- *Hypericum perforatum*
- *Juncus* sp.
- *Leucantheum vulgare* (oxeye daisy)

- *Lewisia triphylla* (threeleaf lewisia)
- *Ligusticum canbyi*
- *Mimulus breweri* (Brewer's monkeyflower)
- *Mimulus moschatus* (musk flower*)*
- *Plantago lanceolata* (narrowleaf plantain)
- *Poa pratensis*
- *Poa secunda* (Sandberg bluegrass)
- *Potentilla flabellifolia* (high mountain cinquefoil)
- *Potentilla gracilis*
- *Potentilla recta* (sulphur cinquefoil)
- *Prunus vulgaris*
- *Rumex acetosella*
- *Senecio triangularis*
- *Solidago canadensis*
- *Spiranthes romanzoffiana* (hooded ladies'-tresses)
- *Synthris missourica*
- *Tiarella trifoliata*
- *Trifolium procumbens* (smaller hop clover)
- *Veratrum californicum*
- *Veronica Americana*
- *Viola adunca*

2.11.5 Population Biology and Viability

Most (80 percent) of the sites on the Idaho Panhandle National Forests contained fewer than 12 plants. Two of the sites (EO #6 and 7) were found in pole-sized stands in upland habitat. EO #5 was found in an impacted wet meadow with past and current disturbance of logging and cattle grazing. The largest population on the Idaho Panhandle National Forests (EO #6) contained 50 plants and was found in *Thuja Plicata/Clintonia uniflora* habitat type in a dry, pole size timber stand along the side of a road with only 10 percent canopy cover.

Monitoring of a *B. simplex* population over several years in the presence of fire confirmed the variable nature of the plants' appearance aboveground (Johnson-Groh and Farrar 1996). On average, less than half of the plants produced aboveground leaves in any given year. The total number of plants and plant size showed no difference between burned and unburned sites in most years. However, fires occurring during or after a drought resulted in population decline, suggesting that plants are killed or severely weakened by this combination of factors (Johnson-Groh and Farrar, 1996).

2.11.6 Summary of Land Ownership and Existing Habitat Protection

Seven of the 14 species found in Idaho are located on the Idaho Panhandle National Forests. One site occurs on the Priest Lake Ranger District (EO #12), three occur on the Bonners Ferry Ranger District (EO #3, EO #4, and EO #6), one occurs on the Sandpoint Ranger District (EO #7), and two are located on the St. Joe Ranger District (EO #5 and EO #15). All of these sites are allocated for timber production in MAs 1, 2, and 3.

2.11.7 Current or Potential Threats to Habitat and Management Activities

All of the sites on the Idaho Panhandle National Forests are located in management areas allocated for timber production. It is quite conceivable that other populations are present, but have not yet been located. Additional information is needed to correctly assess the conservation status of least moonwort in Idaho and clearance surveys on the Idaho Panhandle National Forests's in suitable potential habitat should include *Botrychium simplex* (Lorain, 1990).

2.11.8 Past and Current Conservation Activities

Refer to Section 1.6. One location on the St. Joe Ranger District is in a grazing allotment and has cattle use. This area will be fenced in 2005 (DiGiacomo, 2004, pers. comm.).

2.11.9 Research and Monitoring

Refer to Section 1.7.

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APPENDIX A – Idaho State Special Status Descriptions

Scientific Name	GRANK	SRANK	State	Federal	USFS Reg 1	USFS, Reg 4	BLM
Botrychium ascendens	G2G3	S1	GP3		S		
Botrychium crenulatum	G3	S1	GP3		S		
Botrychium lanceolatum	G5T4	S3	S		S		
Botrychium lineare	G1	SH	GP1	C	S		Type 1
Botrychium 'michiganense'	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Botrychium minganense	G4	S3	S		S		Type 4
Botrychium montanum	G3	S2	GP3		S		
Botrychim paradoxum	G2	S1	GP2		S		
Botrychium pedunculosum	G2G3	S1	GP3		S		
Botrychium pinnatum	G4	S2	S		S		
Botrychium simplex	G5	S2	2		S		

(Note: Region 1 has a new sensitive species list as of October 2004 and Botrychium lineare is listed as sensitive.)

The network of Natural Heritage Programs and Conservation Data Centers, which currently consists of installations in all 50 states, several Canadian provinces, and several Latin American and Carribean countries, ranks the rangewide (GRANK or global rank) and state (SRANK or state rank) status of plants, animals, and plant communities on a scale of 1 to 5. The rank is primarily based on the number of known occurrences, but other factors such as habitat quality, estimated number of individuals, narrowness of range of habitat, trends in populations and habitat, threats to the element, and other factors are also considered. The ranking system is meant to exist alongside national and state rare species lists because these lists often include additional criteria (e.g., recovery potential, depth of knowledge) that go beyond assessing threats to extinction.

Components of Ranks:

G = Global rank indicator; denotes rank based on rangewide status.
T = Trinomial rank indicator; denotes global status of infraspecific taxa
S = State rank indicator; denotes rank based on status within Idaho.
1 = Critically imperiled because of extreme rarity or because some factor of its biology makes it especially vulnerable to extinction (typically 5 or fewer occurrences).
2 = Imperiled because of rarity or because other factors demonstrably make it very vulnerable to extinction (typically 6 to 20 occurrences).
3 = Rare or uncommon but not imperiled (typically 21 to 100 occurrences).
4 = Not rare and apparently secure, but with cause for long-term concern (usually more than 100 occurrences).
5 = Demonstrably widespread, abundant, and secure.
U = Unrankable.
H = Historical occurrence (i.e., formerly part of the native biota; implied expectation that it might be rediscovered or possibly extinct).
X = Presumed extinct or extirpated.
Q = Indicates uncertainty about taxonomic status.
? = Uncertainty exists about the stated rank.
NR = Not ranked.

NA = Conservation status rank is not applicable.

APPENDIX B – Key to Western Species of Moonwort Ferns (Farrar, Pers. Comm., 2005)

1. Leaf divided into trophophore (photosynthetic segment) and sporophore (spore-bearing segment)…**2**
1. Leaf divided into two more or less equal sporophore segments and no trophophore. ***B. paradoxum***

2. Pinnae above the first pair fan-shaped to linear, without a distinct midrib…**3**
2. Pinnae above the first pair pinnately divided or lobed, with a distinct midrib…**15**

3. First pinna pair usually enlarged, often pinnately divided and replicating the remainder of the main axis…**4**
3. First pinna pair not disproportionately larger than second pinna pair, not pinnately divided…**5**

4. Sporophore-trophophore separation near ground level, as far below the first pinna pair as the distance between the first two pinna pairs…***B. simplex***
4. Sporophore-trophophore separation at or near the first pinna pair…***B. pumicola***

5. Pinnae narrowly spathulate to linear or blocky, with sides parallel or diverging at an angle of less than 45°…**6**
5. Pinnae broadly spathulate to fan-shaped, with sides diverging at an angle of greater than 45°…**8**

6. Pinnae blocky and broadly attached to rachis…***B. montanum***
6. Pinnae more or less linear and narrowly attached to rachis…**7**

7. Pinnae narrowly spathulate, often shallowly cleft into non-spreading lobes…***B. campestre***
7. Pinnae linear, often deeply cleft into widely spreading lobes…***B. lineare***

8. Trophophore stalk equal to or greater than the average distance between pinnae…**9**
8. Trophophore stalk shorter than the average distance between pinnae…**11**

9. Plants pallid when fresh, pinnae broadly attached, more or less adnate, basal pinna often shallowly bilobed…***B. pallidum***
9. Plants green, pinnae usually not adnate, usually symmetrical, seldom pinnae…**11**

10. Pinnae ascending (angled toward the apex), longer than broad, firm in texture, margin entire to shallowly lobed…***B. minganense***
10. Pinnae spreading (nearly perpendicular to the rachis), broader than long, thin textured, margin finely crenulate…***B. crenulatum***

11. Basal pinnae with a span of 60° - 100°, often bearing sporangia…***B. ascendens***
11. Basal pinnae with a span greater than 120°, seldom bearing sporangia…**12**

12. Trophophore distinctly stalked, pinna texture thin and delicate, margins crenulate…***B. crenulatum***
12. Trophophore usually sessile or nearly so, pinna texture firm, margins entire to denticulate…**13**

13. Pinnae asymmetrical with the lower side expanded, sporophore stalk, at time of spore release, less than or equal to the length of the trophophore…***B. tunux***
13. Pinnae symmetrical, sporophore stalk, at time of spore release, exceeding the length of the trophophore…**14**

14. Basal pinna span 120° to 180°, with basal inner margin slightly concave…***B. lunaria***
14. Basal pinna span greater than 180°, with basal inner margin strongly recurved…***B. yaaxudakeit***

15. Trophophore lustrous, sporangia yellow-green…**16**
15. Trophophore dull or glaucous, sporangia dull green-brown…**18**

16. Upper pinna bases broadly wedge-shaped (angle > 90°) to cordate, apices rounded, sporophore stalk equal to trophophore length…***B. pinnatum***
16. Upper pinna bases narrowly wedge-shaped (angle < 90°), apices angular, sporophore stalk shorter than trophophore length…**17**

17. Trophophore triangular with basal pinnae often exaggerated, pinna pairs 3-4, pinnae narrowly ovate to oblong…***B. lanceolatum***
17. Trophophore broadly ovate, basal pinnae usually not exaggerated, pinna pairs 5-6, pinnae ovate to elliptic…***B. alaskense***

18. Trophophore stalk longer than the average distance between pinnae, usually bearing sporangia on lower trophophore pinnae…***B. pedunculosum***
18. Trophophore stalk equal to or shorter than average distance between pinnae, seldom with sporangia on lower trophophore pinnae…**19**

19. Basal pinnae oblong to narrowly ovate, usually strongly exaggerated…***B. michiganense***
19. Basal pinnae broadly ovate to triangular, somewhat to not exaggerated…**20**

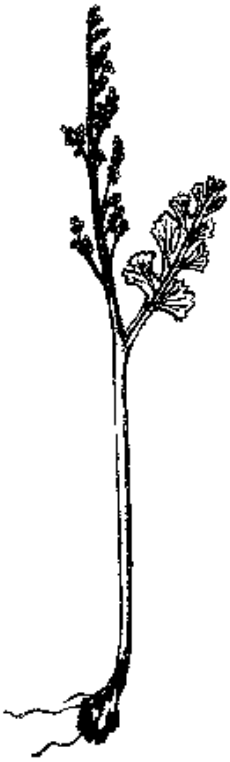
20. Pinna bases wedge-shaped, pinna lobes spreading, sporophore pinnately divided…***B. echo***
20. Pinna bases truncate to cordate, pinna lobes parallel to converging, sporophore divided into three main branches…**21**

21. Pinnae shallowly dissected, pinnae not overlapping…***B. hesperium var. hesperium***
21. Pinnae deeply dissected, strongly overlapping…***B. hesperium var. fenestratum***

APPENDIX C – Species Descriptions and Photographs

Botrychium ascendens

Photo courtesy of Mike Hays; Idaho Conservation Data Center; Idaho Special Status Vascular Plants website; accessed at http://fishandgame.idaho.gov/tech/CDC/plants/vascular_plants_status_a-d.cfm



Courtesy of Walt Fertig, Wyoming Natural Diversity Database, Laramie, Wyoming

Species Description

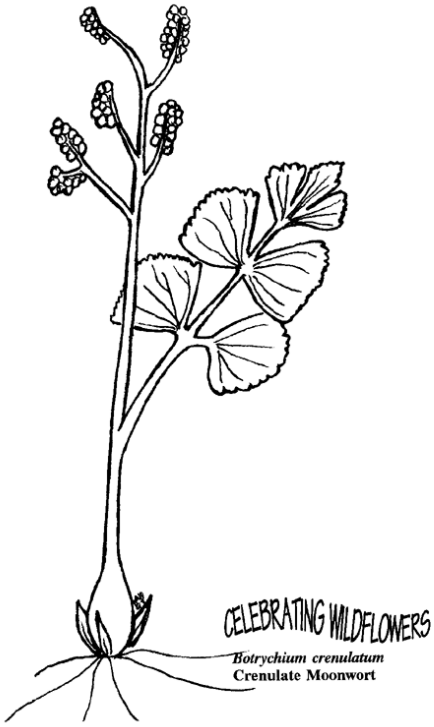
General Non-technical Description: Plants are comprised of a single above-ground bright yellow-green frond that is usually about 10 centimeters (cm) tall. It is divided into two segments that share a common stalk. The mostly sterile segment is once-pinnatifid with as many as ten pairs of strongly ascending, narrowly triangular pinnae that have deeply lacerate margins. There are often a few sporangia on the margins of the lower pinnae of the sterile leaf segment. When mature, the fertile segment is longer than the sterile segment, is branched, and bears grape-like sporangia (ICDC, 2004b).

Technical Description: "Trophophore stalk 3-10 mm, 1/6 length of trophophore rachis; blade yellow-green, oblong to oblong-lanceolate, 1-pinnate, to 6 X 1.5 cm, thin but firm. Pinnae to 5 pairs, strongly ascending, well separated, distance between 1st and 2d pinnae not or slightly more than between 2d and 3d pairs, basal pinnae pair approximately equal in size and cutting to adjacent pair, obliquely narrowly cuneate, undivided to tip, margins sharply denticulate and often shallowly incised, apex rounded, venation like ribs of a fan, midrib absent. Sporophore 2-pinnate at base of sporangial cluster, 1.3-2 times length of trophophre. 2n = 180." from Wagner and Wagner (1993).

Distinguishing Features: *Botrychium ascendens* is known to grow with *B. crenulatum* and *B. minganense* and is similar in appearance to both (Vanderhorst 1997). It can be distinguished from both by its strongly ascending pinnae with sharply serrate or incised margins, vs. the others' usually spreading pinnae with entire to crenulate margins. It differs from *B. minganense* by its bright yellow-green vs. deep, dull green color and by its thinner blade texture (Vanderhors 1997). Although *B. ascendens* is reported as the only moonwort species to commonly have sporangia on the proximal pinnae of the trophophore (Wagner and Wagner 1986, 1993; Mantas and Wirt 1995), this condition has also been observed in *B crenulatum*, *B. minganense, B. montanum*, and *B. pedunculosum* in Montana, and Zika (1992) also reports it for *B. lanceolatum* and *B. pinnatum* in Oregon (Vanderhorst 1997).

Botrychium crenulatum

Photo courtesy of Linda Swartz; Idaho Conservation Data Center; Idaho Special Status Vascular Plants website; accessed at http://fishandgame.idaho.gov/tech/CDC/plants/vascular_plants_status_a-d.cfm



Courtesy of Northwest Wildflower. Drawings by Karl Urban. Accessed at http://www.nps.gov/plants/color/northwest/5.htm

Botrychium crenulatum
Species Description

General Non-technical Description: A thin and delicate, perennial plant with a pale yellow-green color that grows to about 10 cm tall. Plants arise from a single stem that divides into a single fertile and sterile "leaf", both attached near the middle of the plant from a 3-5 cm long common stem. The sterile leaf is attached to the main stem by a short (5 mm) stalk, once divided into 2-5 pairs of lateral segments (pinnae) that are strongly flabellate with entire to shallowly-scalloped outer margin. The fertile portion ranges from 2.5-9.5 cm long (Wagner and Wagner 1981, Lellinger 1985, Wagner and Devine 1989).

Technical Description: "Plants mostly less than 10 (6-16) cm tall, glabrous from the first; sterile blade with short (5 mm) stalk attached near the summit of the plant (the common stalk 3-5 cm long), ovate-oblong to linear-oblong in outline, 2 (0.5-6.5) cm long and 1.2 (0.8-1.8) cm wide, once pinnate; pinnae segments in 3 (2-5) pairs, wedge-shaped or flabellate, the lower and upper margins of the medial pinnae an angle of mostly 100 or more (20 - o o 110), with distinct veins reaching the margins; pinnae margins o subentire to crenulate-dentate, and in very large specimens sometimes with 1-5 incisions; fertile stalk mostly 4.5 (2.5-9.5) cm long" (Wagner and Wagner 1981, Wagner and Devine 1989, Lellinger 1985).

Distinguishing Features: The species inhabits wet, swampy areas at low elevations, generally near western redcedar communities. Dainty moonwort is easily confused with *B. minganense* and *B. lunaria*. The nearest relative of dainty moonwort is *B. lunaria* (moonwort), which is frequently found growing in the same habitat (Lellinger 1985, Wagner and Devine 1989). Small plants of *B. lunaria* can look very much like dainty moonwort, however, dainty moonwort has thin, pale yellow-green fronds, a distinctly stalked sterile leaf, and an average of three pairs of fan-shaped pinnae that are small and remote (generally not overlapping) with decidedly shallowly-scalloped outer margins (Wagner and Wagner 1981, Lellinger 1985). By comparison, *B. lunaria* is bluish-green with a fleshy texture, a sessile sterile leaf, and 4-7 pairs of very crowded, somewhat overlapping, flat pinnae with almost entire margins.

Dainty moonwort can be distinguished from *B. minganense* based on the number and shape of the sterile leaf segments (pinnae), which are numerous and distinctly wedge-shaped and cupped or spoon-shaped *for B. minganense*. Comparatively, *B. crenulatum* has an average of three pairs of flat, fan-shaped pinnae (Wagner and Wagner 1981, Wagner and Devine 1989)

Botrychium lanceolatum

W. Carl Taylor. USDA NRCS. 1992. Western wetland flora: Field office guide to plant species West Region, Sacramento, CA. Courtesy of USDA NRCS Wetland Science Institute.

Courtesy of Northwest Wildflower. Drawings by Karl Urban. Accessed at http://www.nps.gov/plants/color/northwest/5.htm

Species Description

General Non-technical Description: A rather fleshy perennial plant growing from 0.5-3.5 dm tall. Plants arise from a single stem that divides into a single fertile and sterile "leaf", both attached near the summit of the plant from a 3-14 cm long common stem. The sterile leaf is attached almost directly to the main stem (without a stalk), twice divided into lateral branches and has sharply pointed or rounded tips and a shiny dark green color. The fertile portion ranges from 1.5-8 cm long.

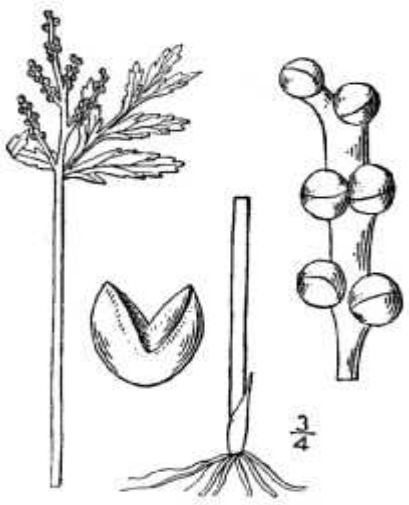
Technical Description: "Plants mostly 0.5-3.5 dm tall, glabrous from the first; sterile blade sessile or nearly so, attached near the summit of the plant (the common stalk 3-14 cm long), deltoid in outline, as wide as or wider than long, commonly 1-6 cm long and 1-9 cm wide, rather openly bipinnatifid or subbipinnatifid, the pinnae and pinnules mostly longer than wide, entire margined with acute to round apices; fertile stalk mostly 1.5-8 cm long; sterile blade and fertile spike both completely reflexed in bud; bud glabrous, wholly concealed by the base of the common stalk" (Cronquist 1969, Lellinger 1985, Wagner and Wagner 1983).

Distinguishing Features: This species grows on wet to moist grassy slopes, roadsides, and edges of lakes generally at fairly high elevations. The sterile frond is once or twice divided with pointed frond tips and a rather fleshy, shiny green appearance. It frequently grows in the same habitat as *B. hesperium*, *B. pinnatum*, and *B. echo* (Wagner and Wagner 1983). Triangle moonwort can be distinguished from these other taxa based on the shape of the sterile portion of the frond, which is broadly deltate (triangular) and nearly sessile in lance leaved moonwort. The sterile leaf is ovate to oblong-deltate and subsessile to stalked in the other three species (Wagner and Wagner 1983).

Botrychium lineare

Photo courtesy of J. Sellers; Idaho Conservation Data Center; Idaho Special Status Vascular Plants website; accessed at http://fishandgame.idaho.gov/tech/CDC/plants/vascular_plants_status_a-d.cfm

Photo courtesy of Susan Spackman; Idaho Conservation Data Center; Idaho Special Status Vascular Plants website; ***accessed at*** http://fishandgame.idaho.gov/tech/CDC/plants/vascular_plants_status_a-d.cfm



Brown. 1913. Illustrated flora of the northern states and Canada. Vol. 1: 6. Courtesy of Kentucky Native Plant Society.

Species Description

Non-technical Description: *Botrychium lineare* is a small perennial fern with a pale green leaf (trophophore) from 6 to 18 centimeters (2 to 7 inches) long. Leaf segments are typically linear and divided or forked at the ends. The sporophore (spore-bearing structure) is 1 to 2 times the length of the trophophore with a single main axis. Both the sporophore and the trophophore arise from an erect subterranean stem. (Zika et al. 1995).

Technical Description: "A perennial with a single pale green, aboveground frond that is 6-18 cm tall. The frond is divided into two segments, one sterile, one fertile, that share a common stalk. The sterile segment is once-pinnate with 4-6 widely spaced pairs of pinnae that are linear shaped or sometimes bifid with linear lobes. The fertile segment is 1-2 times as long as the sterile segment and has a single major axis with short branches that bear grape-like sporangia" (USFWS 2000).

Distinguishing Features: This species is distinguished by the extremely narrow pinnae of the sterile frond segment. It is most similar to *Botrychium campestre*, from which it differs by having more strictly linear pinnae and by having a narrow, thin textured axis of the sterile segment rather than a fleshy and broad one (USFWS 2000).

Botrychium 'michiganense'

Photo courtesy of USFS, Idaho Panhandle National Forest Herbarium, District Headquarters, Coeur d'Alene, Idaho

This is not currently a formally described species; however a draft description from Donald Farrar (2004) was obtained from the author. The species is described as "similar to *Botrychium hesperium* but tending to be narrower with relatively more exaggerated basal pinnae. Especially distinctive are the short, more or less approximate adnate, stubby pinnae above the base, and the tendency toward strongly enlarged basal pinnae, together with a sporophore with three main axes. Young or dwarfed specimens are more or less linear, and the basal pinnae are not exaggerated (from Wagner and Wagner 1990). Apparently tetraploid."

Botrychium minganense

Photo courtesy of Linda Swartz; Idaho Conservation Data Center; Idaho Special Status Vascular Plants website; accessed at http://fishandgame.idaho.gov/tech/CDC/plants/vascular_plants_status_a-d.cfm

Courtesy of Northwest Wildflower. Drawings by Karl Urban. Accessed at http://www.nps.gov/plants/color/northwest/5.htm

Species Description

Non-technical Description: A small, inconspicuous, rather fleshy perennial growing from 3-22 cm tall. Plants arise from a single stem that produces a single fertile and sterile "leaf", both attached near the summit of the plant from a 3-13 cm long common stem. The sterile leaf is once divided into numerous well-developed wedge-shaped segments (pinnae). This sterile leaf is yellowish-green in color and is attached to the main stem by a small stalk often more than 5 mm long. Pinnae are rather remote, spoon-shaped or cupped rather than flat, and not notably wider than long. Outer margins of the pinnae are entire, but commonly with one or more shallow incisions. The fertile frond is 1.5-15 cm long. Plants emerge in late spring and release spores in summer.

Technical Description: "Plants mostly (3) 6-18 (22) cm tall, glabrous throughout; sterile blade on a short stalk about 5 mm long, attached near the summit of the plant (the common stalk 4-10cm long), oblong and distinctly pinnate, with (2) 3-6 (7) pairs of pinnae, commonly 1.5-10 cm long by 0.5-2.5 cm wide, yellow-green in life; pinnae widely cuneate to subflabellate, the lower pinnaewith upper and lower borders at angles of 50-100 , margins entire and rounded, or more frequently with one or more shallow incisions; sterile blade and fertile spike both completelyreflexed in bud and wholly concealed by the base of the common stalk" (Cronquist 1969, Wagner and Lord 1956, Wagner and Devine1989).

Distinguishing Features: This species grows in meadows, prairies, and woods and on sand dunes and riverbanks, in acid to circumneutral soils (Lellinger 1985). Within these habitats the plant is distinguished by a small, yellow-green-colored fern with a single fertile and sterile frond. The sterile frond is once divided with numerous well-developed wedge-shaped segments, often with one or 19 several large incisions on the outer margin. Mingan moonwort can be easily confused with *B. lunaria* and *B. crenulatum*, but is distinguished from these taxa based on the shape of the sterile leaf, which is distinctly wedge-shaped and cupped or spoon-shaped in life. *B. lunaria* generally has very crowded, somewhat overlapping, flat, and mostly fan-shaped pinnae. *B. crenulatum* also has flat, fan-shaped pinnae, but they tend to be more remote and not overlapping (Wagner and Devine 1989).

Botrychium montanum

Photo courtesy of USFS, Idaho Panhandle National Forest Herbarium, District Headquarters, Coeur d'Alene, Idaho

Courtesy of Northwest Wildflower. Drawings by Karl Urban. Accessed at http://www.nps.gov/plants/color/northwest/5.htm

Species Description

Non-technical Description: *Botrychium montanum* is a small perennial fern with a single above ground frond. The frond varies in height up to about 12 cm tall, is a dull glaucous gray-green, somewhat succulent, and divided into two segments which share a relatively short common stalk. The sterile segment is once pinnatifid with well separated, irregular, angular, ascending lobes with entire or toothed margins. The fertile segment is longer than the sterile segment, is branched, and bears grape-like sporangia. Spores germinate underground and develop into minute subterranean, non-photosynthetic gametophytes (Vanderhorst 1997).

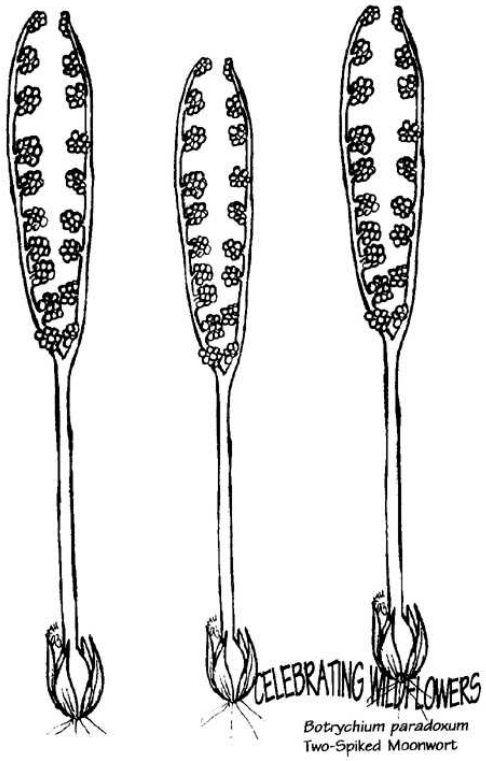
Technical Description: "Trophophore stalk 0.3-2 cm, 0.2-0.5 times the length of the rachis; blade dull, glaucus, gray-green, mostly linear, lobed to 1-pinnate, to 6 X 0.7 cm, somewhat succulent. Pinnae or lobes to 6 pairs, ascending, mostly widely separated, distance between 1st and 2d pinnae not or slightly more than between 2d and 3d pairs, extremely variable in outline, linear to cuneate, undivided to tip, margins entire to coarsely dentate, distal pinnae or blade tip cut into 3-5 lobes, apex angular, venation like ribs of a fan, midrib absent. Sporophores 1-pinnate, 1.5-4.5 times length of sporophore. 2n = 90." (Wagner and Wagner 1993).

Distinguishing Features: Glaucous gray green color, succulent texture, a relatively short common stalk, and irregular angular lobes rather than distinct pinnae are diagnostic of *B. montanum*. Among the moonworts of Montana, *B. montanum* is relatively easily recognized, but may be mistaken for *B. ascendens*, and small plants may be confused with other species (Vanderhorst 1997).

Botrychium paradoxum

Photo courtesy of USFS, Idaho Panhandle National Forest Herbarium, District Headquarters, Coeur d'Alene, Idaho

Photo courtesy of USFS, Idaho Panhandle National Forest Herbarium, District Headquarters, Coeur d'Alene, Idaho



Courtesy of Northwest Wildflower. Drawings by Karl Urban. Accessed at http://www.nps.gov/plants/color/northwest/5.htm

Species Description

Non-technical Description: *Botrychium paradoxum* is a small perennial fern with a single above ground frond. The frond varies in height up to about 15 cm tall, is glaucous green, somewhat succulent, and divided into two similar segments which share a common stalk. The segments may be unbranched in small plants or branched in larger plants and are both fertile and bear grape-like sporangia. Spores germinate underground and develop into minute, subterranean, non-photosynthetic gametophytes.

Technical Description: "Trophophores converted entirely to second fertile segment, stalk 1/2 length of fertile segment. Sporophores double, 2 per leaf, 1-pinnate, 0.5-4 cm. 2n = 180." (Wagner and Wagner 1993).

Distinguishing Features: *Botrychium paradoxum* is perhaps the easiest of moonworts to recognize, being the only species to lack a sterile laminar frond segment, but other species could be mistaken for it if the sterile segment has been browsed or bears marginal sporangia.

Botrychium pedunculosum

Photo courtesy of Jim Vanderhorst; Idaho Conservation Data Center; Idaho Special Status Vascular Plants website; ***accessed at*** http://fishandgame.idaho.gov/tech/CDC/plants/vascular_plants_status_a-d.cfm

Species Description

Non-technical Description: *Botrychium pedunculosum* is a small perennial fern with a single above ground frond. The frond varies in height up to about 20 cm and is divided into two segments which share a common stalk. The lower common stalk is usually reddish brown and the upper part of the plant is a dull glaucous green. The mostly sterile segment is conspicuously stalked and once to twice pinnatifid with up to five pairs of primary pinnae. The pinnae have irregular angular lobes and vary from pinnatifid to bifid to narrowly fan shaped and the lower ones often bear sporangia. The fertile segment is longer than the sterile segment and bears grape-like sporangia; larger plants usually have two large ascending lateral branches. Spores germinate underground and develop into minute, subterranean, non-photosynthetic gametophytes.

Technical Description: "Trophophore stalk 8-26 mm, to 1.1 times length of trophophore rachis; blade dull green, ovate-oblong to deltate-oblong, 1-pinnate, to 4.5 X 2 cm, leathery. Pinnae to five pairs, somewhat ascending, approximate to well separated, distance between 1st and 2d pinnae not or slightly more than between 2d and 3d pairs, basal pinnae pair approximately equal in size and cutting to adjacent pair, ovate-rhombic to spatulate, lobed to tip, margin entire to irregularly lobed, apex rounded to acute, venation pinnate. Sporophores 1-3 pinnate, 2-4 times length of trophophore. 2n = 180." (Wagner and Wagner 1993).

Distinguishing Features: *Botrychium pedunculosum* is a distinctive species that is most similar to *B. pinnatum* and *B. hesperium*, which may also have reddish common stalks and pinnatifid pinnae. It differs from the former by having a stalked trophophore, dull green vs. bright green color, and leathery vs. papery texture. *Botrychium hesperium* is also dull green, but the trophophore does not have a long stalk and the lowest pinnae pair is conspicuously larger than the adjacent pair. The presence of extra sporangia on the basal pinnae of the trophophore and the two large lateral branches of the sporophore are useful characters for identifying *B. pedunculosum*. A narrow brown stripe extending down the common stalk from the trophophore is mentioned in the description of the species (Wagner and Wagner 1986), but this character was not apparent on plants found on the KNF in Montana. Plants found on the KNF are shade forms and have narrower pinnae that are more well separated than typical plants from Oregon, which grow in sunny places (Vanderhorst 1997).

Botrychium pinnatum

Photo courtesy of Robert Moseley; Idaho Conservation Data Center; Idaho Special Status Vascular Plants website; accessed ***at*** http://fishandgame.idaho.gov/tech/CDC/plants/vascular_plants_status_a-d.cfm

Photo courtesy of Mike Hays; Idaho Conservation Data Center; Idaho Special Status Vascular Plants website; accessed at http://fishandgame.idaho.gov/tech/CDC/plants/vascular_plants_status_a-d.cfm.

Courtesy of Northwest Wildflower. Drawings by Karl Urban. Accessed at http://www.nps.gov/plants/color/northwest/5.htm

Botrychium pinnatum
Species Description

Nontechnical Description: A rather fleshy perennial plant growing from 1-2 dm tall. Plants arise from a single stem that divides into a single fertile and sterile "leaf", with the sterile leaf commonly attached above the middle of the plant from a 4-13 cm long common stem. The sterile leaf is attached almost directly to the main stem (without a stalk), once or twice divided into numerous somewhat overlapping lobes with rounded tips and a shiny bright to yellow-green color. The fertile portion ranges from 1.5-8 cm long (see Appendix I for line drawings).

Technical Description: "Plants mostly 1-2 dm tall, glabrous from the first, a bright to yellow-green in color, shiny in life; sterile blade sessile or nearly so, attached near or more commonly above the middle of the plant (the common stalk 4-13 cm long), ovate or ovate-oblong in outline, mostly 1.5-7 cm long and 1-4.5 cm wide, somewhat fleshy, bipinnate or subbipinnate, the pinnae mostly 3-6 pairs, the ultimate segments blunt or rounded at apex, not much if at all longer than wide, entire margined with rounded apices, somewhat crowded, prominently veined with twice forked veins; pinnae in large plants pinnately cut and closely resembling the whole blade of a smaller plant; fertile stalk mostly 1.5-8 cm long; fertile stalk mostly 1-4 cm long, exceeding the sterile portion, fertile spike 1.5-6 cm long; sterile and fertile portions wholly concealed by the base of the common stalk" (St. John 1929, Cronquist 1969, Lellinger 1985, Wagner and Wagner 1983).

Distinguishing Features: The species grows on wet to moist grassy slopes, streambanks, roadsides, and in mossy woods generally in the mountains and is distinguished by a small bright- to yellow-green-colored fern with a single fertile and sterile frond portion. The sterile frond is once or twice divided with rounded frond tips, rather fleshy, and has somewhat crowed pinnae. It grows in the same habitat as *B. hesperium* and *B. lanceolatum* (Wagner and Wagner 1983). Northwestern moonwort can be distinguished from these other taxa based on the shape of the sterile portion of the frond, which is lanceshaped to ovate in outline, bright to yellow-green in color with numerous, fleshy, somewhat overlapping lobes in northwestern moonwort. Additionally, the pinnae are nearly symmetrical, not ascending or clasping, and blunt to rounded at the apex. *Botrychium hesperium* is quite similar to northwestern moonwort, however, *B. hesperium* is a dull, gray-green in color with few pinnae lobes and the lowest lobe is exaggerated, strongly asymmetrical, ascending, and somewhat clasping. The sterile leaf in *B. lanceolatum* is distinctly triangular, shiny dark green in color with narrow, pointed pinnae (Wagner and Wagner 1983).

Botrychium simplex

Photo courtesy of USFS, Idaho Panhandle National Forest Herbarium, District Headquarters, Coeur d'Alene, Idaho

Britton, N.L., and A. Brown. 1913. Illustrated flora of the northern states and Canada. Vol. 1: 3. Courtesy of Kentucky Native Plant Society.

Species Description

Nontechnical Description: A small, somewhat fleshy, perennial growing from 3-13 cm tall. Plants arise from a single stem that divides into a single fertile and sterile "leaf", attached to a common stem seldom more than 2.5 cm long. The sterile leaf is attached from ground level (common in our area) to high on the common stalk and is highly variable in shape and size. The sterile leaf can be simple or more commonly divided into three main branches (ternate), each with 2-4 pairs of pinnae, the lowest generally the largest. Pinnae fan-shaped, flat, slightly overlapping with entire, rounded outer margins. The fertile portion ranges from 2-8 cm long.

Technical Description: "Plants mostly 3-13 cm tall, glabrous from the first; sterile blade with an evident, sometimes sheathing petiole, gen. 1.0-3.5 cm long, attached from ground level (common in our area) to high on the common stalk, which is seldom more than 2.5 cm long; sterile leaf highly variable from simple to broadly ternate with 3-main pinnate branches each with 2-4 pairs of pinnae at maturity; pinnae segments subflabbellate to oblong, the lowest one commonly larger than the others, margins generally entire with rounded apices, flat, often approximate; fertile stalk mostly 2-8 cm long; sterile blade and fertile spike both erect or nearly so in bud; bud glabrous, wholly concealed by the base of the common stalk" (Cronquist, 1969, Lellinger, 1985, Wagner and Devine, 1989).

Distinguishing Features: Least moonwort grows on moist to rather dry open, grassy meadows and woods in deep shade and duff (Lorain, 1990). This species appears as a small, somewhat fleshy fern with a single fertile and sterile frond portion. The sterile frond is long-stalked, often attached at ground level and variable from simple to three main branches with fan-shaped segments that slightly overlap (see Appendix I). Larger, mature plants of least moonwort are difficult to confuse, since no other species in this area has a sterile leaf that is divided into three main branches. Smaller plants, however, could be confused with *Botrychium crenulatum* or *B. lunaria*. Least moonwort can be distinguished from these taxa based on the shape of the sterile portion of the frond, which is generally attached near ground level and has few fan-shaped pinnae that somewhat overlap. In contrast, *B. lunaria* and *B. crenulatum* have once pinnate sterile leaves that attach to a distinct common stalk and both species have broadly fan-shaped pinnae (Lorain, 1990). Additionally, *B. lunaria* is fleshy, bluish-green in color with 4-7 pairs of very crowded pinnae that overlap and *B. crenulatum* is herbaceous, yellow-green in color with an average of three pairs of separate pinnae that do not overlap and have distinctly crenate margins (Wagner and Devine, 1989; Cronquist, 1969).

APPENDIX D – Glossary

achlorophyllous - lacking chlorophyll; appearing without green color.
acute - sharp-pointed, with more or less straight margins which form an angle of less than 90 at the tip. o
antheridia - in cryptogams, the organ corresponding to an anther that produces male gametes; the male organ on the prothallium.
apex - terminal portion of a structure (generally refers to leaves).
approximate - similar parts that are close together and often overlapping or touching at the edges.
archegonia - the flask-shaped female reproductive organs on the prothallium in the higher cryptogams corresponding to a pistil in the flowering plants and containing the egg which becomes the sporophyte.
ascending - inclined upward.
asymmetrical - having a different outline on each side of a central axis.
axis - the central line or structure along which parts or organs are attaches. Plural Axes.
bipinnate or twice-pinnate - twice pinnate, the pinnae again pinnate; divided into pinnae bearing pinnules.
clasping - attached directly and usually somewhat surrounding.
cleft - cut about half way to the base; deeply lobed.
crenate - shallowly-scalloped, with rounded teeth.
crenulate - minutely crenate.
cuneate - wedge-shaped or triangular, with the narrow end at the point of attachment; forming an angle of 30 to 45 degrees with the two other sides straight.
deltate - broadly triangular with an obtuse apex
deltoid - shaped more or less like an equilateral triangle, with one of the sides as the base.
dentate - bearing spreading, pointed teeth; directed outward from margin rather than forward.
distant - similar parts that are well separated and not overlapping or touching at the edges.
endophytic - fungi or bacteria, which for all or part of their life cycle, invade the tissues of living plants and cause unapparent and asymptomatic infections entirely within plant tissues, but cause no symptoms of disease.
elongate - much longer than wide.
entire - an even or smooth margin, not toothed or lobed.
fertile - bearing sporangia (spore cases). Antonym - sterile
flabellate - fan-shaped
flagellates - cells with flagella but no cell wall.
frond - the leaf of a fern
gametangium - The organ producing the gametes.
gemma (pl. gemmae) - a bud or body analogous to a bud by which a plant propagates itself.
glabrous - lacking glands, hairs, and scales.
herbaceous - a plant with stems that die back to the ground at the end of the growing season; not woody.
heterotrophic - an organism that requires chemical energy from already formed organic molecules; dependent on organic food made by photosynthetic plants.
imbricate - having similar parts that overlap.
incised - deeply and sharply cut.
lacerate or laciniate - cut into narrow and usually unequal segments.
lamina - the expanded portion of a frond, the leaf blade of a fern. Plural laminae. lamina that is narrowed at the base. Plural - pinnae. See segment.
lanceolate - lance-shaped, with a long, tapered apex and a short, tapered base.
linear - long, narrow, and of uniform or nearly uniform width

lobe - a projecting segment of an organ.
lunate - shaped like a small crescent or half-moon
margin - an edge of a flat structure, usually a lamina or pinnae.
medial, median - pertaining to the middle.
oblanceolate - the inverse of lanceolate; gradually narrowed.
oblong - longer than wide with the long sides mostly parallel; shaped more or less like a geometric rectangle.
obtuse - forming an angle of 90% or more with the 2 sides straight or slightly convex.
orbiculate - circular in outline, or nearly so.
ovate - having the outline of a longitudinal section of a hen's egg; similar to elliptic except broadest towards the base rather than at the middle.
pinna - a stalked or sessile, primary division of a compound.
pinnate or once-pinnate - with 2 rows of lateral branches or appendages, or parts along an axis, like barbs on a feather; once divided into pinnae.
pinnatifid - deeply lobed, but not cut to the axis, and the lobes not contracted at their base
prothallus - a cellular, usually flat and thallus-like growth, resulting from the germination of a spore, upon which are developed sexual organs or new plants. The gametophyte stage of ferns.
recurved - curved backward or downward.
remote - see distant.
rhomboidal - diamond-shaped, often much longer than wide
saprophytic - feeding from dissolved or decayed organic material, as a saprophyte.
segment - a portion of a lamina, pinna, or pinnule that is fully attached and with a deep sinus on each side that extends more than half was from the segment apex to the axis that the segment is attached to.
sessile - attached directly without a stipe or stalk.
spatulate - shaped like a spatula, rounded above and narrowed to the base.
sporophyte - spore-bearing part of the moss
stalk - a short, supporting axis, as the petiolule of a segment or pinna.
sterile - lacking sporangia (spore cases). Antonym – fertile.
stipe - the stalk of a frond from the base of the lamina to the point of attachment to the rhizome; the petiole of a fern.
sub- - a prefix indicating a lesser degree of a characteristic; meaning under, almost or not quite.
symmetrical - having a similar outline on both sides of a central axis. Antonym - asymmetrical
ternate - divided into 3 equal or subequal parts.
toward the base and widest at the apex.
truncate - appearing as if cut off perpendicular to the axis.
ultimate - of the lowest order; the smallest division.
venation - the type or kind of vein pattern.
vesicular - composed of or covered with vesicles; inflated like a bladder

APPENDIX E – Element Occurrence Data Table

APPENDIX F – Element Occurrence Data Maps